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FILE TITLE

C-FQBL 28-3-79
FAIRCHILD F-27

TITRE DU DOSSIER

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02-0122

VOL. 2

NO. 5002-H900

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"This accident was investigated to provide guidance toward the prevention of a recurrence. The content of this report is confined to relevant circumstances and is published for accident prevention purposes only."

REPORT # H90001
AIRCRAFT ACCIDENT
QUEBECAIR FLIGHT 255
FAIRCHILD F-27 CF-QBL
QUEBEC CITY, P.Q.
18:51 EST, MARCH 29, 1979

SYNOPSIS

On 29 March, 1979, Quebecair Flight 255 took off on runway 06 at Quebec City airport. Shortly after lift-off there was a loud bang from the right engine. The section of the engine from the low pressure compressor forward separated and fell to the ground, including some cowlings. Fire broke out in the engine and nacelle.

The aircraft was seen making a low right hand circuit apparently attempting to make an emergency landing at the airport. With the fire continuing the aircraft flew, at a slow airspeed, for one minute twelve seconds, then crashed approximately 4200 ft from the button of runway 30. An intensive fire broke out on impact consuming the flight deck and parts of the wings.

Fourteen passengers and three crew members died in the crash. Seven passengers survived.

This accident was investigated and this report was prepared by the Aviation Safety Investigation Division, Aviation Safety Bureau, Transport Canada.

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Honourable the Minister of Transport

This Accident Investigation and this Report have been audited by the Aircraft Accident Review Board. The Board has considered all information available including that from involved parties. The Board agrees with the contents of this Report for release as public information.

Aircraft Accident Review Board

M.T. Friedl, (Chairman)

F. R. Thurston

R. J. Baker

B. M. Deschênes

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Figure	1	Aircraft Path
	2	Composite Diagram with CVR Information
	3	Impact Site-wreckage Plot
	4	Runway Wreckage Plot
	5	Damage to Right Side of F-27 ST-AAA
	6	Fire Damage to CF-QBL
	7	Climb Performance CF-QBL After Damage
	8	Distance/Height Performance After Damage

Appendix	A	Quebec Airport Approach Plate, Rwy 06
	B	SID Departure
	C	Single Engine Climb Out Procedure, Rwy 06
	D	Engine Failure Procedure
	F	Engine Failure Climb Profile

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1. FACTUAL INFORMATION

1.1 History of Flight

On 29 March, 1979, a Fairchild F27 (C-FQBL), operating as a scheduled passenger flight, departed Dorval at 13:00 EST (18:00 GMT)* to Quebec City as Flight 270. The itinerary was then to Montreal Mirabel airport as Flight 285 and returning to Quebec City as Flight 252. Flight 252 arrived at Quebec at 17:28, with Flight 255 scheduled to depart at 18:45. There were no crew changes.

At 18:37:40 Flight 255 requested IFR clearance from Quebec Ground Control on frequency 121.9 mHz. Ground Control issued the clearance at 18:37:49 which read "255 cleared to Dorval Airport, 316 Felix direct Dorval, take-off 06, number one SID".** The clearance was acknowledged and read back correctly. At 18:43:52 Flight 255 requested taxi clearance. Ground Control cleared 255 to runway 06 via the Bravo taxiway, runway 30 and the Golf taxiway giving the wind as calm and instructing 255 to contact Quebec Tower on 120.3 mHz when on the Golf taxiway.

On Golf taxiway, the crew performed the standard before take-off check (see figure 1). At 18:46:28 they called the tower for take-off clearance. At 18:46:34 tower cleared Flight 255 to line up on runway 06 and at 18:46:54 Flight 255 was cleared for take-off, with instructions to contact Quebec terminal on frequency 119.5 mHz after take-off.

The Captain was flying and the take-off roll started at 18:48:43, as was indicated by the Captain's remark "Here we go" on the cockpit voice recorder.*** At time 17 seconds the First Officer called "dry power normal both sides." At time 23 seconds the First Officer called "70 knots" as was required by the Company's standard procedure. At time 29 the Captain started to rotate slowly lifting the nose gear off the runway. The main gear oleo legs started to extend, closing the squat switch which started the flight data recorder. At time 31, a thumping sound from the extension of the landing gear oleo legs indicated that the aircraft became airborne. The calculated airspeed was 95 kts IAS.****

At time 36 there was a loud bang from the right engine as it disintegrated and a severe fire developed. The aircraft was at approximately 103 kts IAS and 40 ft above the runway.

* *All times are local time, eastern standard time, (GMT minus 5 hours).*

** *SID Standard Instrument Departure.*

*** *For analysis purposes, Captain's remark "Here we go", at 18:48:43 is considered to be time 0.*

**** *I.A.S. Indicated Airspeed, for CAS, (Calibrated Airspeed), add 4 kts.*

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At time 42 the Captain started the engine failure/fire emergency drill. At time 45 the tower controller who had noticed flames from the right engine advised Flight 255 that the right engine was on fire and authorized them to land on any runway. From time 50 to 1:05 the crew attempted to raise the landing gear which never came up.

The aircraft climbed to about 120 ft above the runway elevation and started a right turn, apparently in an attempt to complete a short circuit, remain visual and execute an emergency landing on the airport. At time 1:14 the Captain called for the propeller to be feathered. Up to this point the crew did not know that the right engine had separated at the first stage impeller and the forward section of the engine along with the propeller and some cowling had fallen onto the runway. At time 1:24 #1 fire bottle was fired and the aircraft continued in a right turn at about 100 ft above the terrain at very low airspeed. The engine fire continued (see Figures 1 and 2).

As the aircraft approached the College de Sacre Coeur the angle of bank increased and the aircraft started to descend until impact. Impact occurred in a nose-down, right wing low attitude at approximately 80 kts. A fierce fire broke out and most of the fuselage forward of the wing was consumed by fire.

At impact the landing gear was down and locked, flaps were in the take-off position (16.5 degrees) and the left engine was developing full power, (refer 1.16.3).

The accident occurred on a dark night under an overcast sky with the visibility one mile in fog.

Impact occurred at 18:50:31, 1 min and 48 seconds from time 0 (take-off) and 1 min and 12 seconds from the "bang" (engine explosion). The impact point was approximately 4200 ft from the threshold of runway 30, 710 ft to the north of the runway centerline and about 80 ft below the runway elevation, (see Figure 1).

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	3	14	0
Serious	0	6	0
Minor/None	0	1	0

1.3 Damage to Aircraft

The aircraft was destroyed by impact damage and fire.

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1.4 Other Damage

There was no other damage.

1.5 Personnel Information

The Captain was 31 years of age and occupied the left pilot seat. He held a valid Airline Transport Licence endorsed for the F-27 and BAC 1-11. He was employed by the Company in September 1974 and promoted to Captain on F-27 aircraft in December 1978. His total flying time was 5200 hours. He had accumulated a total of 2434 hours before joining the Company. His total time on the F-27 prior to the accident was 565 hours, of which 249 hours were as pilot-in-command.

His total flying time in the previous seven days was 26 hours, and in the previous 30 days he had flown 84 hours. In the previous 90 days he had flown a total of 185 hours. His last line check was flown on the 23 February 1979, and his last proficiency check was on 29 November 1978. Both checks were successfully flown on the F-27 aircraft. He passed his last medical examination on 22 January 1979. He had been off duty for three days prior to reporting for this flight, and his duty time prior to the accident was 7 hours and 35 minutes.

The First Officer was 27 years of age and occupied the right pilot seat. He held a valid Airline Transport Licence endorsed for the F-27. He was employed by the Company in March 1978 and was checked out and assigned as a F-27 First Officer on 10 April 1978. His total flying time was 4787 hours of which 687 hours was on the F-27.

His total flying time in the previous 7 days was 6 hours, and in the previous 30 days 72 hours; in the previous 90 days he had flown 195 hours. His last proficiency check was flown on the F-27 on 20 September 1978 and his line check was conducted on 4 January 1979. He passed his last medical examination on 14 September 1978. He had been off duty 2 days prior to reporting for this flight. His duty time prior to the accident was 7 hours and 35 minutes.

The Flight Attendant was 24 years of age and was qualified to act as attendant on board the F-27. She was hired by the Company in May 1977 at which time she commenced her training. Her last recurrent training was in April 1978.

1.6 Aircraft Information

(a)	Type:	Fairchild F27
	Manufactured:	Fairchild Industries, Inc. Fairchild Republic Company Hagerstown, Maryland in 1959
	Serial Number:	47

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Owner:	Quebecair, Montreal, Quebec
Certificate of Airworthiness:	Valid
Certificate of Maintenance:	Valid
Total airframe time:	41,077:29 hrs; 53,052 cycles
Total airframe time since major overhaul:	10,820:33 hrs

Last "A" Check completed at: 41,067:21 hrs on 27 March 1979. All mandatory airworthiness diretives and maintenance orders had been completed.

The aircraft was manufactured under U.S., FAA type certificate 7A1 and was purchased new by Quebecair in July 1959. It was imported into Canada and given a Certificate of Airworthiness, No. 0501178.

The aircraft was certified and maintained in accordance with DOT approved procedures and all modifications were incorporated. There were no deficiencies reported prior to the last take off.

(b) Engine and propeller data:

Powerplants: Rolls Royce Dart 514-7
Propellers: Dowty Rotol model R/175/4-30-4/13E

Item	Serial Number	T.T.S.N.	T.S.O.	Cycles since Overhaul
Engine (L)	3065	36937:20	2791:45	3306
Engine (R)	12023	34069:55	2259:57	2696
Propeller (L)	59/215	22014:40	987:47	N/A
Propeller (R)	58/113	16225:22	2975:01	N/A

Item	Serial Number	Overhaul Date	Agency	Installation date on C-FQBL
Engine (L)	3065	11/4/77	Rolls Royce Canada	26/2/79
Engine (R)	12023	4/10/77	Rolls Royce Canada	4/4/78
Propeller (L)	59/215	9/1/78	Semsa Incorp.	12/9/78
Propeller (R)	58/113	25/10/77	Dowty Rotol	8/11/77

These times and cycles are within the manufacturers' recommended time between overhaul. The left engine accumulated some of its time, since overhaul, installed in another aircraft.

(c) The aircraft's operational empty weight was 25,546 lbs plus the baggage and ballast, which by actual weight was 1110 lbs, for a total weight of 26,656 lbs. The weight for 21 passengers was 3388 lbs, giving a total zero fuel weight of 30,044 lbs. At

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take-off there was 5900 lbs of JP4 fuel and 106 lbs of water-methanol on board, bringing the gross weight to 36,050 lbs. The maximum allowable gross weight on take-off for this aircraft is 40,500 lbs and the centre of gravity limits are 20% to 38% MAC, with the gear down. On take-off Flight 255 was within these limits.

1.6.1 Weight and Balance Calculations

Three detailed weight and balance calculations were made: one for the take-off, one for when part of the right engine fell off, and one for just prior to impact.

Passenger seating arrangement was obtained from witness information. This included the seating arrangement at take-off and the seating changes that occurred as a result of the explosion and engine fire. At take-off the aircraft gross weight was 36,050 lbs and the C of G was at station 376.44, (35.95% MAC).*

When the front section of the engine, propeller and cowlings fell off, the gross weight decreased to 34,957 pounds and the C of G moved rearward 3.73 inches, to station 380.17, (39.63% MAC).

Just prior to impact, after some passengers moved to the rear, the C of G shifted further to the rear by 3.60 inches to station 383.77, (43.18% MAC) The final C of G was 5.25 inches behind the aft limit. (Refer LP 99/79).

1.7 Meteorological Information

The regional forecast described a low pressure area which was to track north of Quebec City in the late afternoon. A cold front extending southwestward from the low was to pass over Quebec City near 1900 29th March. Overcast clouds up to twelve thousand ft were forecast with low ceilings and showers near the front. The terminal forecast for the airport amended at 1625 called for ceilings between six and fifteen hundred ft and visibilities as low as one-quarter of a mile in fog and rain. The forecast issued at 1730 called for ceilings between five and eight hundred ft with visibility again as low as one-quarter mile in drizzle and fog. An improvement was indicated after 1900 but with a continuing risk of three hundred and one-quarter. Winds were forecast to be light. Light to moderate rime icing in cloud was forecast and the freezing level was to be near the surface at the front.

The weather conditions at the time of take-off are taken from the 1900 observation: sky partially obscured, 100 ft scattered, measured ceiling 600 ft overcast, visibility 1 mile in fog, msl pressure 1019.7 mbs, temperature 1°C, dewpoint 1°C, wind 230 at 8 kts

**Mean Aerodynamic Chord*

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altimeter setting 30.01 in Hg, fog 1/10, stratus fractus 2/10, stratus 7/10. A special weather observation was not taken because a scheduled synoptic observation was in progress at the time of the accident. The observer was in fact at the weather instrumentation site, adjacent to the terminal building, and was a witness to the accident.

The surface wind had been calm from 1425 to 1800; the 1825 special observation gave the wind as 240 deg at 3 kts. No icing was reported at low altitude and the stability of the airmass, as well as the light winds, suggest no turbulence.

Sunset occurred at 1805 with night therefore commencing at 1835.

1.8 Aids to Navigation

All airport lighting, navigation and approach aids were checked within 3 hours of the accident; they were all serviceable and not a factor in the accident.

1.9 Communications

Quebec Tower controls air traffic within the Quebec positive control zone (radius 10 nm, to 4000 ft asl).

Quebec Terminal control unit provides services to IFR flights and also provides flight information in the airspace delegated by Montreal Center. All communications between the accident aircraft and the tower were in French. Communication was not a factor in the accident.

1.10 Aerodrome Information

The Quebec airport (46° 48'N 71° 24'W) is located about 12 miles northwest of downtown Quebec City, in the City of Ste-Foye. To the north is the Laurentide mountain chain with summits 1,200 to 1,400 ft a.s.l. at a distance 7 to 10 miles from the airport. Airport elevation is 239 ft.

Quebec airport is owned and operated by Transport Canada under public licence and is classed as an "A" category airport.

The airport has two runways with associated taxiways to facilitate aircraft movement.

Runway 06-24: 7,500 ft x 150 ft (2,286 m x 45.7 m), category "A", ILS front course with glide path approach to 06, and an ILS back course approach to 24.

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Runway 12-30: 5,700 ft x 150 ft (1,737 m x 45.7 m), category"B", with ADF approach to runway 30. Runway 12 is restricted to VFR traffic.

1.11 Flight Recorders

The aircraft was equipped with a Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR). Both were recovered but only the CVR provided some useful information.

The FDR was a Fairchild 15600-502 analogue foil recorder, Serial No. 5801. The unit was located in the tail, aft of the lavatory, and sustained no damage from impact or fire. This FDR system is not designed to function from start-up to shutdown. The FDR circuit is completed when a squat switch on the right main gear closes on take-off when the oleo extends. On this flight, the FDR started, but when the right engine disintegrated the circuit was damaged and the FDR stopped. It is considered that the recording lasted for only 3 seconds and provided no useful information. Due to lack of information from the FDR calculated data was used for this report.

The CVR, *a Collins 642C-1, Serial No. 655, was recovered from the radio rack behind the First Officer's seat. The rear part of the external case was burned extensively, but the front part was in good condition. The internal protective container was apparently not damaged by impact or fire. The tape showed no sign of damage, but it was not possible to play it back in the recorder due to a seized speed reducer.

On playback it was found that the recording was of very poor quality, with marked distortion on the Cockpit Area Microphone (CAM) and audio channels. There was a thirteen minute period recorded during the accident flight, beginning when the crew entered the cockpit before start-up, and ending at or immediately before impact.

In analyzing the CVR recording, filtering and other electronic techniques were used to enhance readability, but these had limited effect due to the distortion present. A transcript was prepared with assistance from F-27 pilots familiar with the accident crew. Despite considerable effort, it was not possible to determine what was said by the crew in several instances. Speech analysis was attempted without success. The formants characteristics of each vowel sound could not be determined from voice prints because the frequency range of the formants contained too much noise. This noise and the distortion also frustrated attempts to determine engine RPM using sound spectrum analysis.

* *Relevant information from the CVR, Cockpit Voice Recorder, is incorporated in this report.*

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It was not possible to determine the reason for the poor quality of the recording.

1.12 WRECKAGE AND IMPACT INFORMATION

1.12.1 Wreckage Observation

Initial contact with the ground was made by the right wing tip which scraped the ground, the direction and nature of the ground scrape giving an approximation of an aircraft heading of 239 deg magnetic (M) at the point of initial contact. The wing tip scraped the ground for about 21 ft prior to the major impact. During this time the aircraft rotated to the right until the right main gear and right engine stub impacted the ground. The butt of the right wing and center section of the fuselage then impacted. This was followed by impact of the left engine and propeller group.

Pitch and roll attitudes of the aircraft at the point of initial ground contact were approximated from structural deformation of the right wing tip. It was possible to measure a deformation angle relative to the terrain which was converted into a right wing low attitude of about 14 deg. Similarly, a pitch nose down angle of 20 deg - 25 deg was also calculated. This pitch angle was considered a maximum and was probably 10 deg - 15 deg less at the point of initial contact of the wing tip.

The location of the ground scars indicated a right to left cartwheel effect which created a line of impact holes heading approximately 10 deg greater than the wing tip scrape mark of 239 deg M. The relative locations of the impact holes indicated that the aircraft had yawed due to ground contact to a final impact heading of 339 deg M. The general distribution of wreckage in relation to the ground scars indicates a strong sideward component of velocity and indicates the aircraft was skidding to the left just prior to impact.

During the sequence of impacts the total integrity of the aircraft was destroyed (see Figure 3). The aircraft separated into five major sections before coming to rest: left and right wings, cockpit area, main fuselage and empennage.

Both main and nose landing gears were found in the down and locked position. The flaps were at 16.5 degrees. The rudder trim was in the full left trim position and the elevator trim was full nose down. The aileron trim was damaged to a point where no readings were possible.

The fire wall shut-off on the right engine was closed and #1 fire extinguisher bottle had been fired. The right wing electric fuel shut-off valve, upstream of the collector tanks, was open. Examination of the aircraft's control system revealed that all flight controls were serviceable at the time of the accident.

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Both the left and right water methanol tank valves were closed.

The landing gear ground locks were found inside the fuselage, indicating that they had been removed prior to take-off.

The landing gear selector lever was found in the mid position, (Refer Section 1.16.6, Test and Research, landing gear selector).

The section of the right engine forward of the low pressure impeller was found on the runway. The top, inboard, and outboard cowlings were also found on the runway. The bottom cowling stayed attached, flipped down and back coming to rest against the main landing gear drag strut.

The left engine had broken into two major sections at impact and was separated from the airframe. The front section forward of the low pressure impeller, complete with propeller, was found half buried in a hole. The aft section was found in the approximate centre of the crash site. The auxiliary accessory gear box was some distance away from the main wreckage.

The tail section and main fuselage were approximately 120 feet from the main impact. The flight deck was completely destroyed by fire.

1.12.2 Break-up Sequence

Initial break-up of the aircraft started with separation of the propeller and front section of the right engine. The engine separated at the first stage impeller section. Engine pieces were scattered along a 1300 ft section of runway 06 starting at about the 3800 ft mark where the "bang" occurred. The major piece of the separated portion of the right engine was found furthest along the runway, (see Fig. 4 and Appendix "E").

When the initial failure occurred, engine pieces were ejected through the cowlings. One major impact hole of approximately 25 square inches was observed in the inboard cowl and corresponded to a location on the fuselage above the window line at about fuselage station 267-277. A hole of approximately 7 square inches was observed at a similar location in the outboard cowl.

The remainder of the aircraft wreckage was found within an area of approximately 250 by 150 feet, in a scatter pattern starting from the point of initial ground contact (see Figure 3). An analysis of the location of ground scars and examination of wreckage pieces found in the impact crater enabled determination of the probable impact and break-up sequence. As initial contact was made with the ground, the first piece to separate from the aircraft was the right wing tip fairing and position light, followed by a 3 ft outboard section of right aileron and upper wing portion. As the wing tip continued to scrape along the ground the wing started to buckle and fold up at

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approximately wing station 519 and separated at about wing station 479. The remainder of the right wing, outboard of the engine, continued to break up due to impact loads.

The right main gear then impacted the ground followed by impact of the stub of the right engine. Complete separation of the right wing likely occurred at this time, caused by failure of both wing fittings in a combined aft bending and torsional overload manner. The butt of the wing and sections of the fuselage then impacted the ground and the remaining aft section of the engine continued to separate from the wing and break up. The main portion of the remaining aft section came to rest about 100 feet from where the engine first impacted the ground. The remainder of the right wing containing the main landing gear was flipped over the aircraft and came to rest inverted about 70 feet from where wing separation occurred.

The left engine and propeller impacted the ground about 43 feet from where the right engine impacted. The left engine propeller and reduction gear box remained buried in their initial impact hole. The rest of the engine from the low pressure compressor back to the tail pipe with engine cowlings attached separated and came to rest 31 feet away. The left wing failed in an upward and forward bending direction at both wing fittings. The wing separated from the fuselage taking the over-fuselage section and came to rest about 100 feet from the left engine impact hole.

During the impact sequence from the right to left engine, the nose section impacted the ground. There was no obvious impact crater and structural damage in the nose area indicated a relatively flat pitch attitude. Selective damage to the radome and to the nose gear doors indicated a right roll attitude of 27 deg. During this time the fuselage and tail section separated and were thrown free to land inverted approximately 120 feet from the main impact zone. The fuselage failed in a bending overload manner due to inertia loads and the tail section broke free as the separated portion of the fuselage impacted the ground.*

1.13 Medical and Pathological Information

Pathological examination of the three crew members did not reveal the presence of any prior medical condition which may have impaired their performance.

It was noted that both the Captain and First Officer had been subjected to extensive burns and that their hearts were ruptured. Also there was food in their stomachs but no evidence of soot in their tracheas. These findings indicate that both pilots were killed on impact and that the burns were caused by the ensuing fire. Biochemical determinations did not reveal the presence of carbon

**Refer Lab Wreckage Retrieval Catalogue*

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monoxide, or alcohol in the blood. Post mortem tissue lactate profiles suggest that the Captain had an acute stress reaction of approximately 15 to 18 seconds, while the First Officer had a stress reaction of approximately 8 seconds.

Pathological findings on the Flight Attendant indicated that this crew member died on impact of cerebral hemorrhage and skull fracture. A flailing injury to the right leg was also noted. Biochemical determinations indicated that there was no evidence of ethanol ingestion. A post-mortem tissue lactate profile indicated that this crew member had an acute stress reaction of approximately 7 seconds.

A drug scan for commonly used drugs carried out on the Captain and Flight Attendant was negative.

Examination of the fatally injured passengers revealed that they had suffered from severe head injuries including skull fractures. Flailing injuries to limbs were also evident. Only one passenger who had been killed on impact, suffered from post-crash burns. Approximately two thirds of the passengers showed some evidence of having worn their seat belts.

From the injury pattern noted on the bodies of the passengers who did not survive, and statements from those who survived, it is believed that had more passengers taken the crash position, that is, heads down with arms over their heads, more passengers may have survived the impact forces of about 9 G's. At least 2 survivors were not wearing seat belts and one of these was seated in row 6, while another was seated to the rear of the aircraft. The fact that some passengers were wearing seat belts while others were not, did not appear to alter the injury pattern.

1.14 Fire

After the engine separated, an in-flight fire broke out in the engine nacelle. Initially the fire was of high intensity. One witness saw flames extending down the landing gear strut. Surviving passengers stated that as the flight progressed the fire decreased in intensity, confined to the wheel well and trailing flames about 5 to 8 feet to the rear of the nacelle. The intensity of the fire probably decreased after the pilots activated the fire handle shutting off the fluids at the engine firewall, but the fire continued until impact.

The fuel tanks ruptured on impact and a severe fire broke out. The forward section of the fuselage and flight deck area were consumed by fire; parts of both wings were also damaged by fire. The main fuselage, aft of the wings, and the tail empennage were the only sections not damaged by the post impact fire, (Refer Fig. 6).

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1.15 SURVIVAL ASPECTS

1.15.1 Crash Response

The duty fire chief saw the aircraft through the fire station window as it passed by at an altitude of about 50 to 75 feet with an engine on fire. At the same time 18:49:30, the crash bell sounded. Two crash vehicles each with two firefighters, immediately left the fire station and called Quebec Ground on 121.9 mHz at 18:49:56. The Tower cleared the vehicles to take positions along runway 06. Before the firefighters reached the assigned positions they saw the fire from the crashed aircraft, off the airport, in the approach area to runway 30. The two vehicles then proceeded toward the crash site via the main access road. Tower personnel alerted the Ste-Foy fire, police and ambulance services.

The crash vehicles located the scene at about 1856. The accident site was in a pasture across a railway track and was therefore inaccessible to the crash vehicles from that point. One vehicle back tracked to the College and attempted to reach the wreckage but got stuck in wet snow in the school yard. At the same time the fire chief and two firefighters ran to the site with portable fire extinguishers. They found the wreckage completely in flames, except for the rear fuselage which had separated from the rest of the wreckage. There were intermittent explosions from the burning wreckage. Several Ste-Foy policemen and firemen were already at the site rescuing the injured. Two ambulances arrived about 5 minutes after the firefighters.

About 55 minutes was required to extinguish the fire. All passengers were evacuated from the site within 25 minutes.

1.15.2 Crashworthiness & Survivability

Analysis of the crash forces (acceleration) was performed using the parameters of impact velocity, angle of impact, aircraft and ground deformation at impact, and the pulse shape to determine their magnitude and direction. Separate crash force calculations were made for the flight deck and the passenger cabin areas. These crash force calculations are considered approximate and are based on the methods used in crash kinematics by a leading university.

For the flight deck it was calculated that the crash force sustained horizontally was 20 G forward for a pulse duration of 0.11 seconds. The crash force in the vertical direction was 80 G downward for a pulse duration of 0.08 seconds. The resultant crash force was 82 G.

From examination of the terrain and fuselage deformation it was concluded that impact of the fuselage was primarily in the vertical direction. Crash forces were therefore calculated in the vertical direction and were 9.4 G for a pulse duration of 0.23 seconds.

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The flight deck section was considered non-survivable since the decelerative loads were in excess of the limits of human tolerance. In addition, the surrounding livable space was destroyed due to deformation and post-impact fire.

The passenger cabin area was considered to be generally survivable since most of the impact energy was absorbed in the structural deformation and extensive break-up of fuselage and wings, and there was no post-impact fire in this area. The energy absorbing sequence of the structural break-up resulted in relatively low peak G loading in the passenger cabin section. Impact of the inverted fuselage with the ground after separation resulted in survivable crash forces and it was significant to note that impact loading in the aft cabin was of only minor intensity. The two most rearward seats were still intact and the aft galley area did not show any impact damage.

All but two of the passenger seats were torn free and ejected out of the cabin section during the latter stages of the crash sequence. The lips of the mounting track failed but the tracks remained attached to the floor structure.

All passengers were thrown out through the forward opening of the fuselage.

1.16 TESTS AND RESEARCH

1.16.1 Right Engine

The low pressure impeller on the Rolls Royce Dart series engines is a single entry, centrifugal type, directly coupled to the turbines. It has provisions for the injection of water/methanol through drilled passages in the hub. The impeller is 20 inches in diameter and made of Hiduminium RR58, a Rolls Royce proprietary aluminum alloy material. It is bored, splined, and it contains 19 vanes. The rotating assembly, consisting of the impeller and rotating guide vanes is axially clamped by the impeller nut. The unit is life limited by the number of cycles attained after each time the bore is re-broached in accordance with successive modifications 797, 1455 and 1676. One of these modifications may be accomplished at overhaul. One cycle is considered to be one take-off and one landing.

On the original design the rear abutment face of the impeller bore contacted the steel sealing sleeve which caused a fretting problem. To eliminate frettage to the mating surfaces under oscilatory torsional loading, Service Bulletin DA72-430, (modification 1732) was issued on July 30, 1976 with the lastest revision in August 1977. This bulletin required the installation of a antifrettage shim between the impeller hub rear abutment face and the mating surface of the sealing sleeve in conjunction with rework per Dart Repair Scheme number 528 (removal of existing fret marks from rear abutment face of the Low Pressure Impeller). The shim is

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0.018 inch thick, S/SJ2 material and is coated with P.T.F.E. which is a type of Teflon material. Service Bulletin DA-72-294, (modification 1455), which was issued on April 18, 1967 with the latest revision in July 2/76, required the deepening of the spline roots to prevent fatigue cracks which propagate from the highly stressed spline roots of the impeller. Service Bulletin DA 72-402, (modification 1676), which was issued on February 16/73 with the latest revision on July 2/76, required the removal of fatigued metal from the bore of the low pressure impellers that had been reworked to modification 1455. Service Bulletin DA 72-A401 was issued in February 26/73 with the lastest revision on February 6/74. This defines the new life for low pressure impellers that comply with modifications 797, 1455 and 1676. A new part number is then issued. For the failed impeller, the new part number was RK 46582.

Physical and records examination indicated that the failed impeller, original P/N* 41842, S/N** SZ551, was removed from the time expired engine, (S/N 12023), in 1977. The impeller had a total time of 7033 hours and 8800 cycles. Modifications 1676 and 1732 were carried out as per Rolls Royce Service Bulletins, DA72-402 and DA72-430 respectively.

The impeller (P/N RK46582) was subsequently released for return to service having 7033 hours total time and "0" cycles. It was considered eligible for a further 11,250 cycles having complied with S/B DA72-A401. The impeller was re-installed in engine S/N 12023 by Rolls Royce at overhaul and subsequently released as a completely overhauled engine on 4 October 1977. 2259:57 hours of operation and 2696 cycles after the modifications had been accomplished, the impeller failed.

1.16.2 Sequence of Impeller failure

The low pressure impeller, found on the runway, had split into two nearly equal parts (Photo 1 and 2). When it failed, centrifugal energy threw the impeller halves against the steel diffuser ring, heavily damaging it and breaking the diffuser retaining bolts. This in turn ruptured the interstage guide vane assembly. The compressor's magnesium casing which forms a major part of the engine structure shattered as a result of being struck by the failed pieces. The bursting of the casing caused major damage to the cowlings. Wobbling of the forward section of the engine shattered the low pressure impeller/rotating guide vane shaft. The top and both side panels became detached from the aircraft and the bottom panel swung down and back, coming to rest against the main landing gear drag strut. The torque sensing unit, detecting a power decline, initiated propeller auto feather. This action was terminated at approximately 54° blade angle when the engine front section moved forward and down, severing the power cables to the feathering motor.

* *P/N:- Part Number*
** *S/N:- Serial Number*

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Most fuel lines were damaged or pulled from their sockets and fuel under booster pump pressure was being sprayed in the engine compartment. Sparks from the tearing metal and/or from the severed electrical cables ignited the fuel. As the engine reduction gear case, complete with the propeller, fell from the aircraft tumbling, the propeller spinner contacted one of the right main tires. Approximately 1093 lbs of material fell off the right engine when it disintegrated. The intensity of the fire subsided when the crew shut off the fuel emergency shut off valve. Fire suppression via the engine fire extinguisher bottles would most likely be ineffective without cowlings to contain and direct the extinguishing agent.

Laboratory report LP77/79, "First stage impeller failure", is a complete technical analysis of the failed impeller. This report indicates that during the impeller rework in 1977 the existing fretting induced fatigue crack on the rear abutment face was not fully removed by Dart Repair Scheme 528. The crack was subsequently not detected by the mandatory inspection using the post emulsifying penetrant method. While in service, the undetected crack grew to critical size over an extended period of time until the impeller burst under normal take-off imposed operational stresses (Photos 3 & 4).

A post-accident fluorescent penetrant test was carried out on the damaged impeller, using test procedure similar to those required for D.R.S. 528. A faint indication of a similar but smaller precrack was visible. Another penetrant inspection was performed using the solvent removable system method. This test produced a more prominent indication which was easier to detect. The solvent removable penetrant system is considered to be more sensitive in the detection of extremely tight cracks than the post emulsifying method. The laboratory also considers an appropriate eddy current inspection technique would be more sensitive than penetrant methods in detecting tight cracks such as observed in this impeller. The eddy current inspection would however require a more highly skilled and experienced operator to carry out the inspection.*

1.16.3 Left Engine

Dismantling and examination of the left engine, propellers and auxiliary accessory gear boxes disclosed that all units had been functioning normally prior to the crash. The left propeller pitch angle was 24 degs at impact. This pitch angle is consistent with high engine power and an airspeed below 85 knots. This was further confirmed by the internal condition of the engine.

* *Rolls Royce regards tight cracks packed with debris as being beyond the capacity of any penetrant system used under shop conditions. Accordingly they changed to a dual inspection system involving both etch and eddy current method in May 1979.*

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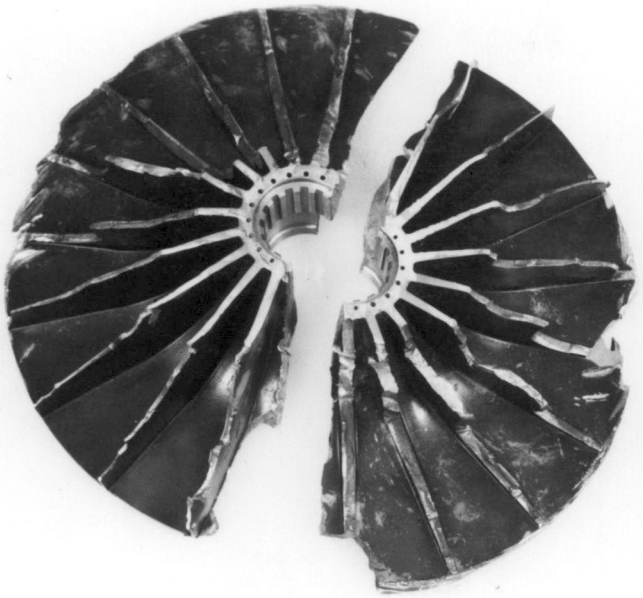

PHOTO 1 - AS-RECEIVED FIRST STAGE IMPELLER REMNANTS, FORWARD FACE.

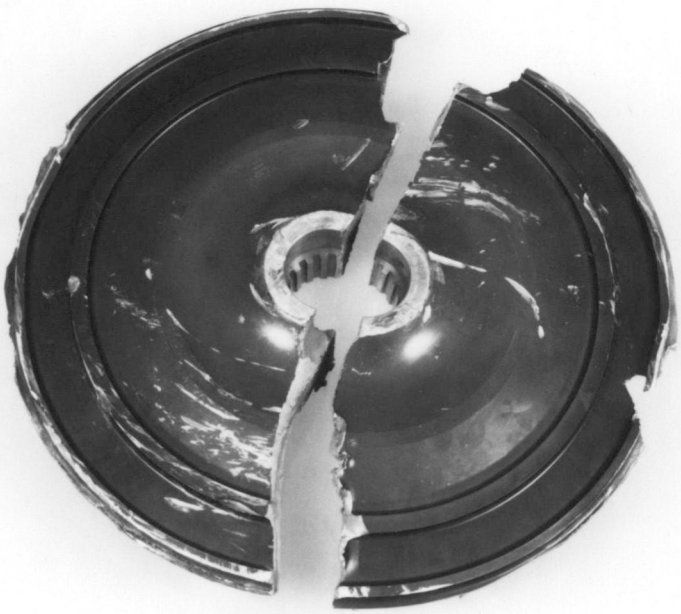

PHOTO 2 - AS-RECEIVED FIRST STAGE IMPELLER REMNANTS, REAR FACE.

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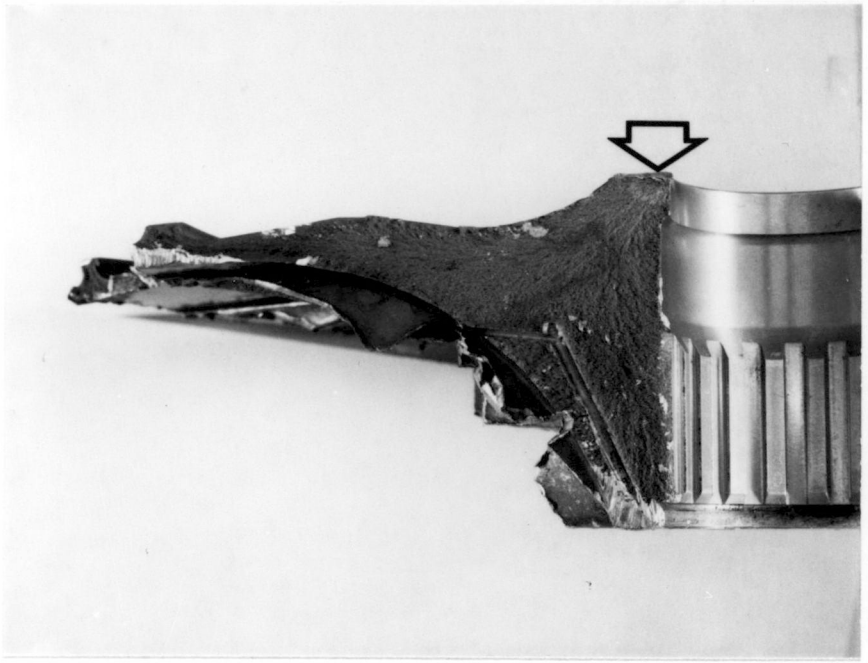

PHOTO 3 - PRIMARY FRACTURE FACE OF THE FIRST STAGE IMPELLER. ARROW IDENTIFIES THE PRECRACK ZONE, WHICH CAN BE IDENTIFIED AS THE VISUALLY LIGHTER ZONE ON THE FRACTURE FACE.

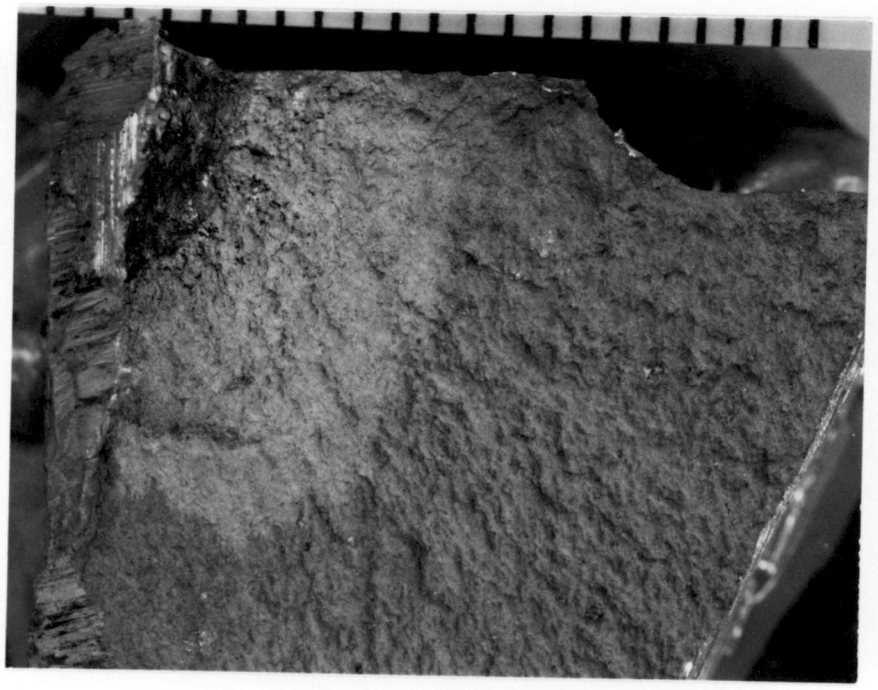

PHOTO 4 - CLOSE-UP OF PRECRACKED LIGHTER APPEARING ZONE AT IMPELLER FRACTURE ORIGIN. TOP SCALE IS MILLIMETERS. NOTE "ANGLED" DARKER ZONE AT TOP LEFT, AND POST-FRACTURE MECHANICAL DAMAGE AT LEFT (REAR ABUTMENT FACE).

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Records examination indicate that both engines and propellers were being operated within the manufacturers recommended time between overhaul.

1.16.4 Fluid Analysis

Analysis of the fluid samples obtained from the aircraft after the crash indicated that the fuel, engine lubricating oil and the water/methanol were within the required specifications.

1.16.5 Landing Gear Solenoid Valve

Extension and retraction of the landing gear is accomplished by actuators operated by pneumatic pressure. Pressure to the actuators is controlled by a pneumatic solenoid valve located in the pneumatic compartment. This valve functions electrically in response to the selected position of the landing gear control handle. The valve is a two-position plunger type valve directing pressure to raise or lower the landing gear. This valve was in the gear down position at impact.

DC power from the flight emergency bus runs to a landing gear handle locking solenoid. A microswitch, mounted on the left main gear strut, closes as the strut is extended and completes a circuit which releases the gear handle locking solenoid. The gear lever may now be selected "UP". Electric power is now directed through a nose-wheel centering switch to the pneumatic solenoid valve. The valve moves to the gear up position, directing air pressure for gear retraction.

1.16.6 Landing Gear Selector

Laboratory examination of the landing gear selector unit revealed that the locking solenoid latch was retracted, allowing an up selection. It also showed that the landing gear lever had been in the "UP" position prior to impact but the gear was found down and locked. (Refer Lab report LP 131/79)

This is consistent with landing gear retraction problems indicated on the CVR.

Since the pneumatic solenoid valve was found in the gear down position, it indicates that electric power for the "UP" selection was not received by the valve and the problem was in the electric circuitry.

1.16.7 Pre-impact fire

To determine whether any extensive in-flight fire existed in the right wing and if an explosion may have occurred prior to impact,

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all retrievable components of the right wing were gathered for reconstruction. Examination of the re-assembled right wing revealed that all fire damage to the wing structure was post-impact in nature and that the pre-impact fire in the engine nacelle was not extensive. It was concluded from field examination and reconstruction that all structural damage to the aircraft was due to impact loads and post-impact fire.

1.16.8 F-27 Impeller Failures Comparison

On 15 October 1972 a Fokker F-27, registration I-ATIZ, took off from Fiumicino airport in Rome when the left engine separated at the low pressure impeller and fell onto the runway.

The FDR indicated that the aircraft was at 100 ft, the airspeed was 112 kts IAS and the landing gear was up when the engine disintegration occurred. The pilot managed to climb to 600 ft AGL and make a successful landing at the airport. There was extensive damage to the left side of the aircraft. Because of the propeller's rotation most of this damage was inflicted by the propeller as it moved inboard after separation.

The circumstances surrounding this incident differed considerably from flight 255; i.e.

a) It occurred in daylight with excellent visibility.

b) The aircraft was well above the V2* speed with the gear up.

c) The aircraft had more powerful engines, (approximately 300 H.P. more).

d) The fire went out.

e) There were no flight path obstructions.

f) The C of G did not move aft of the rear limits when the forward part of the left engine fell off.

There was another F-27 incident, registration ST-AAA, at Khartoum Airport in Sudan on 6th March 1974. During the take-off roll an explosion was heard and the pilot aborted the take-off. The right engine was completely severed at the low pressure impeller casing and hanging down. The engine disintegrated due to impeller failure, which was almost identical to QuebecAir Flight 255, except that the failure occurred early in the take off roll and the aircraft stopped a short distance from the starting point. The extent of the damage sustained to ST-AAA at Khartoum is shown in Figure 5.

* *Take off safety speed.*

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Since it was also the right engine that failed on Flight 255, it is reasonable to assume that similar damage was sustained to the forward section of the fuselage. It is believed that there was probable damage between station 122 and 154.4 as is evident by the failure of the gear to retract and the cycling of the primary VHF radio. Unfortunately any evidence of damage to the forward section of the fuselage was destroyed by fire.

In CF-QBL the radio rack which also includes the electrical control panel, is installed on the right side of the fuselage between stations 122.0 and 154.4, and all the electrical wiring to and from the radio rack is in a common area aft of station 122.

The routing of the wiring for a gear up selection is from the gear select lever to the radio rack area thence to the landing gear solenoid valve. Therefore, a failure of the wiring between the lever and the solenoid, especially in the vicinity of the radio rack area, would not only prevent the landing gear to retract but could also create an electrical short causing the VHF radio to cycle.

1.16.9 Simulator Tests

Several investigators proceeded to an airline simulator centre to evaluate the FH-227 simulator for possible use in establishing performance data of the accident aircraft. No actual F-27 simulators exist in North America. An attempt was made to configure this simulator, as close as possible, to Flight 255.

Numerous take-offs were made in an attempt to duplicate the drag, flight path and control problems of Flight 255. After take-off the right engine was failed with a simultaneous shift of the C of G aft to simulate the change which occurred on Flight 255. Since the maximum aft C of G limit of the simulator was 39.4% MAC, a further shift rearward to 43.18% to simulate the C of G just prior to the impact was not possible. The results were inconclusive and were not significantly accurate for use as factual performance data.

1.16.10 Aircraft Flight Profiles

Five flight profiles were flown at Quebec Airport using a company F-27 aircraft. The profiles were all flown at an average altitude of 400 feet ASL, (150 - 200 feet above ground), and with varying degrees of turn in order to approximate the flight path of C-FQBL as derived from CVR and witness information. The same witnesses observed the flights and reported that the altitude of the aircraft was too high on all five runs. One run approximated the flight path of Flight 255 and the results were used to plot the probable track in Figure 1.

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1.16.11 Certification Performance F-27

The Critical-Engine-Failure Speed V_1, (equals V_2), is the maximum speed at which power failure can be experienced during the take-off run and the airplane stopped within the scheduled runway length. Speed V_1, (equals V_2), is also the minimum speed at which power failure can be experienced and the take-off continued without penetrating below the scheduled take-off flight path clearance plane.

The Takeoff Safety Speed, V_2, is the scheduled speed for take-off and climb, by CAR regulation. Two basic Take-off Safety Speed Schedules, V_2 Minimum and V_2 Maximum, have been established for varying climb and field length requirements. In addition, intermediate, or optimum, V_2 speeds may be used for specific conditions. For the F-27/F-27B airplane, speed V_1 equals V_2.

The V2 Minimum Schedule, provides the shortest possible field length requirements at some sacrifice in the maximum weight permitted by climb requirements.

The V2 Maximum Schedule permits the highest possible take-off weights based on climb requirements provided take-off field length requirements are not limiting factors.

On this flight V_2 maximum, (103 kts IAS), was the target speed.

If an engine failure occurs after V_1, (equals V_2), the aircraft is not certified to stop within the confines of the runway. The pilot's option to abort the take-off therefore no longer exists.

The take-off flight path is based on the following criteria. Failure of the critical engine is assumed to occur during take-off at speed V_1 which equals V_2. After lift-off the landing gear is selected UP and V_2 is maintained to a height of 400 feet. At 400 feet the aircraft is levelled off and accelerated to the flap retraction speed. The flaps are then retracted and the aircraft accelerated to the enroute climb speed, and the climb continued to 1000 feet, (refer Appendix E).

1.16.12 Company Abnormal Operating Procedures QuebecAir Operating Manuals

a) General: In all abnormal situations, crews are to carry out the appropriate "memory items" and then to refer to the emergency check-list for the remainder of the procedure.

b) Engine Failure or Malfunction before V2: Should a malfunction occur on the take-off roll, it will be called out

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clearly; if the airspeed is below V_2 an abort shall be called and carried out as follows:

1) Power levers.....closed
2) G.F.P*.....selected
3) Flaps.....zero
4) Maximum braking

c) Engine Failure on Take-off after V2: Although the following procedure is tailored for an engine power loss on take-off, it can be generally applied to any airborne power loss.

STRAIGHT: - step on the ball
- climb runway track to 1,000' or follow Company SID,
- maintain V_2.

POWER: - Ensure take-off power

DRAG: - When positive rate of climb - L/G up

HPC - CONFIRM & FEATHER - FEATHERING BUTTON - PUSH/LIGHT OUT
- Use "dead foot - dead engine" and confirm

CHECK FOR FIRE: If fire evident:
FIREWALL SHUT-OFF - CONFIRM & PULL
EXTINGUISHER - FIRE SHOT ONE (Take time)
30 secs later: FIRE SHOT TWO

In order to conform to the F-27 single engine climb criteria, flap retraction will not be carried out below 400' AGL. In addition, crews are to maintain the V_2 climb until it has been confirmed that there is no fire or until one shot has been fired into the engine.

After level-off, accelerate to flap retraction speed, call "flaps 11, flaps 0, Meto Power". When applying meto power, increase trimmers 30% turn methanol off and trim engines for 14,500 rpm and 650 degrees.

After flap retraction, accelerate to S.E. climb speed and maintain this speed to quadrantal altitude if returning to the airport or to MEA if proceeding enroute.

Declare an emergency and state intentions and perform cockpit clean-up with reference to the emergency check-list. Carry out after take-off checks.

To meet obstacle clearance. The Company's single engine climb out procedure for departures on runway 06 at Quebec is: track the localizer to the Champlain (BV) non-directional beacon, then right turn to the localizer to the Quebec (QB) non-directional beacon, (Refer Appendix C).

* *Ground fine pitch.*

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1.16.13 Performance Calculations

Performance Calculations were made from the original aircraft flight test and certification data which was supplied by Fairchild Republic, the aircraft manufacturer. Details of these calculations are contained in report number NRC/NAE LTR-LA-235.

To obtain the aircraft performance values the following conditions were used:

1. Aircraft Gross Weight - 36,000 pounds
   Flap Position - 16.5°
   Landing Gear Position - Down
   Runway elevation - 239 Feet Above Sea Level
   Outside Air Temperature - +1°C; (ISA -14°)
   Engine(s) at Maximum Continuous Power
2. Five seconds from start of throttle advance to full throttle.
3. Aircraft lift off was at time 31 (CVR thump sound).
4. Aircraft accelerated in ground effect with wheels off the runway to 107 kt CAS (103 kt IAS).
5. Climb started at 107 kt CAS and continued at 107 kt until "bang" 36.0 seconds from time 0, ("Here we go").
6. Debris from the engine was projected perpendicular to the flight path and some debris particles retained the aircraft forward velocity during fall to ground.
7. Tail wind experienced throughout take-off run was 5 knots.
8. Undercarriage rolling resistance coefficient was increased from 0.025 to 0.030 due to wet (partly) runway.

Calculations produced the following performance information:

Take-off Sequence of Events

Time sec.	Event	Speed Kts CAS	Distance from end of runway Ft ± 50
0.0	Here we go	0.0	130
2.0	Start throttle advance	0.0	230
7.0	Full throttle	7.0	260
31.0	(Thump) Lift-Off	98.9	2775
34.1	Start of Climb	107.0	3340
36.0	"Bang"	107.0	3700
	1st group #26 debris hits runway	107.0 (112.0)*	3850
37.8	Last group #26 debris hits runway	107.0 (112.0)*	4050

* *Ground speed*

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Aircraft lift-off occurred at time 31; the airspeed was 98.9 kts, CAS, (94.9 kts IAS).

When the "bang" occurred the height of the aircraft wheels was 44 ft above the runway, (refer figure 8).

Assuming that the aircraft energy height remained constant after the "bang", ie, speed at "bang" was 107 kts CAS and the height gained was 100 feet, the airspeed would have decreased to 96.4 kt CAS.

After the loss of part of the starboard engine, the aircraft weight dropped from 36,000 pounds to 34,880 pounds. The missing engine firewall was exposed (10.94 sq. ft.) and 6.42 sq. ft. of the lower engine cowling was also exposed; the landing gear was down.

The following performance calculations are based on the aircraft configuration after damage.

The single engine, wings level, maximum climb is 15.6 FPM at an optimum airspeed of 87.0 kt CAS. At VMC, 81 kts, it would be 4.2 FPM and at 91 kt, (V2 minimum), it is 11 FPM. At 103 kt, the target V2, it would change to a descent rate of approximately 55 FPM.

With 15 degs bank, climb rates changes to 34.7 FPM descent, at 87.4 kt CAS. At VMC, 81 kts, the descent rate would be 48 FPM, and at 91 kts (V2 min) it is 39 FPM, (refer figure 7).

The minimum control speed (air) for the aircraft configuration after loss of engine and the center of gravity at Station 382.67" is approximately 80.6 knots CAS; 2.6 knots greater than that quoted in the Aircraft Flight Manual for flaps 16.5° and the propeller feathered.

Since aircraft performance, for certification, must be done by demonstration, the above data by calculation may not be absolutely accurate.

1.16.14 Flight Reconstruction

At approximately 1837 the flight crew boarded the aircraft and performed the pre-start check. The Captain gave a departure briefing including the Company's engine failure climb procedure for runway 06 (see also 1.16.11, last para)

The station agent came aboard with the weight and balance and load sheet which was checked and signed by the Captain. The Captain called out the weight as 36,000 lbs and the First Officer responded with, "okay, two dry, 103, 106 and 116". This refers to: engines dry for take-off, V2 103, flap retraction, speed 106 and enroute climb speed 116.

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The engines were then started and the pre-taxi checks were completed, and the crew informed the Flight Attendant of the flight time and altitude and confirmed the passenger count to be 21.

The aircraft departed the gate at 1844 and commenced to taxi to runway 06.

During taxi all checks were done in accordance with the aircraft check list. After the aircraft taxied onto the runway it stopped momentarily permitting the crew to complete their final check. At 18:48:43 the Captain called, "Here we go" and started the take-off.

When the engine disintegrated at time 36 the airspeed was 107 kts CAS and the aircraft was about 40 feet above the runway. The aircraft continued to climb to about 120 ft AGL at which time the airspeed had decreased to 96 kts CAS, (92 kts IAS). The pilots were now already below their target V2 speed of 103 kts and no further climb was possible.

At time 42 the Captain called out the emergency procedure: "Straight, Power Max Power". There was no "Gear Up" verbal call on the CVR but a visual gear up signal was probably given soon after "Power Max Power", as indicated by the Captain's remarks "Okay" at time 50. Evidence from the CVR indicates that the crew were now also faced with a failure of the landing gear to retract. This second emergency probably interrupted their actions in performing the emergency checks. At time 45 Tower advised the crew of the fire and cleared them to land. From about time 50 to 1:05 they tried to get the landing gear up. At about time 55 the aircraft started turning to the right; the airspeed continued to decrease. At 1:09 the First Officer asked if he should feather; the Captain called "Feather" and the high pressure cock was moved to feather at 1:10. Apparently the crew did not know that the forward section of the engine had fallen off up to this point. (refer Figure 2).

The CVR revealed that at time 1:09 the Communications radio trans/receiver cycled from 120.3 mHz to 121.0 and at about time 1:15 it again cycled to 121.9 mHz, where it remained until impact. Although the cause of the cycling could not be determined, it is unlikely that the busy crew would take time to change frequency when communications with the tower was well established.

The aircraft continued at approximately 120 ft AGL with the airspeed decreasing, but the crew could not give up altitude for airspeed without striking obstacles.

Soon after the engine explosion a fire developed which, according to witnesses, enveloped the engine cowlings and nacelle. The fire is believed to have prompted the Flight Attendant to proceed forward to advise the Captain, however there is no evidence to

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indicate if the Attendant actually reached the cockpit area. At about time 1:20 to 1:30 the Flight Attendant returned to the cabin and briefed the passengers for an emergency landing. She also began to move passengers seated nearest the fire to seats across the aisle, however three or four passengers spontaneously moved to the rear seats in the cabin. This moved the C of G further rearward, 5.25 inches, beyond the aft limit. This no doubt further aggravated the control problems experienced by the crew. The aircraft was by now approaching the college.

Calculations indicated that the average bank angle for the circuit was about 15° and the descent rate would have been about 40 ft per minute. In order to maintain altitude the crew would have to give up airspeed. The C of G shift occurred at about the time the crew most likely saw the red obstruction lights on top of the College. Two things could have happened at this time; the aft C of G movement may have caused the aircraft to pitch up, or the pilot may have pulled back on the elevators to avoid the college. The results would be the same. The airspeed dropped below VMC causing loss of directional control with the rudder. The aircraft was seen banking sharply to the right followed by a high sink rate. Several seconds prior to the impact the First Officer called out "watch out". The landing lights were on and this warning was most probably the First Officer sighting the ground. First impact was with the right wing tip with approximately 14 deg of bank and 10 to 15 degs nose down. Impact occurred as the aircraft was yawing to the right, (skidding to the outside of the turn), an indication that the aircraft was below VMC. Impact occurred between VMC (81 kts) and the stall (76 kts).

With an engine emergency shortly after lift-off, failure of the gear to retract and an aircraft that would not climb, the crew were faced with a serious problem. Their reactions are reflected on the CVR. At Quebec airport all circling for runway 06 must be done to the south-east because of rising terrain to the north-west. This ruled out a left turn. The inability of the aircraft to climb made it impossible to adhere to the single engine departure procedure of climbing straight ahead, (refer Appendix C).

The crew's awareness of these problems is evident when they attempted to do a right turn back to the airport at a very low altitude. Had the crew attempted to continue straight ahead in accordance with departure procedures the aircraft would have struck obstacles within 5 N.M., or less, from the end of the runway.

1.16.15 The Carrier

Quebecair is a regional carrier based at Dorval Airport. It operates Convair 580, BAC 1-11, Boeing 707, 727, C-130, and F-27 aircraft. The BAC 1-11 and F-27's are used for scheduled domestic flights.

The Company's Operations Control Centre is located at Dorval Airport. The functions of the Control Centre are basically aircraft

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dispatch and flight watch which is conventional and adequate. The centre is usually staffed 24 hours a day.

All F-27 ground school, initial flight, and refresher training is conducted by company personnel at the company's facilities at Dorval. Since no simulator is used, all flight training is done on company aircraft. The pilots are subjected to simulated engine failure at V2 and also simulated engine failure on a baulked approach and overshoot.

The training is in accordance with Transport Canada's requirements as laid down in ANO Series VII Number 2.

Agents are employed by the company for the loading of aircraft and for weight and balance calculations. These agents are given five weeks training and another six months under supervision before they are considered competent to perform these duties. Other duties include ticket sales and passenger handling.

1.16.16 Video

The video Camera was used for re-flying the flight path and for wreckage study.

1.17 Witness Information

There was generally a consensus of opinion from witnesses relating to the various phases of Flight 255. Prior to flight, cargo handlers and ramp personnel did not observe any unusual circumstances associated with Flight 255 and described pre-flight preparation and departure as a normal operation.

Tower Control stated that the aircraft lined up and stopped prior to starting the take-off roll. The aircraft travelled some 3800 ft along the runway and was at a height generally estimated at 30 to 40 ft when the explosion occurred. Various witnesses compared the sound of the explosion to a cannon shot, a piece of metal striking the ground or an unusually loud noise. Some saw rather than heard the explosion. The fire associated with the explosion was depicted as being yellow to orange in colour and covering the whole of the right engine area, extending back sufficiently to illuminate the side of the aircraft. Immediately following the explosion the fire was bright and highly visible but decreased in intensity so that the last witnesses to see the aircraft described the fire as confined to the interior of the engine nacelle and discernible only from ahead. Witnesses in the terminal and ramp area lost sight of the aircraft in the vicinity of the Quebec government hangar. One witness residing just to the east of Aéroport Blvd, the road that runs roughly north/south on the east side of the airport, stated that he heard a loud explosion followed by a sound similar to an aircraft applying reverse thrust. He heard the aircraft approach and first observed it flying at low altitude in a southerly heading on the west

.../28

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side of Aéroport Blvd. He stated that the aircraft was banked slightly to the right and that the right engine was trailing a flame 5 to 8 ft in length.

Three witnesses on the porch of College du Sacré Coeur observed the aircraft approaching from the north at an altitude estimated at 200 ft. They were unaccustomed to seeing aircraft in this sector. They noted the landing lights illuminating ahead of the aircraft then saw smoke trailing from the right engine and realized that the right engine was on fire. The aircraft was in a slight turn to the right and as it overflew the west corner of the residence it started an abrupt turn to the right and crashed. Another witness residing just south of the crash site, observed the aircraft approaching from the north. Initially he noted a glow, then recognized the lights of the aircraft with the right engine on fire. He estimated the altitude as 75 to 150 ft and stated that the aircraft flew for some 4 to 5 seconds, initiated an abrupt right turn, crashed to the ground and exploded in a ball of flame. After advising the police and fire departments, he proceeded to the accident scene to help in rescue operations. A substantial number of witnesses rushed to the accident scene to render assistance.

As the first rescuer arrived at the scene several minutes after the crash there was a secondary explosion in the forward part of the aircraft, ostensibly from a wing tank. The fire was mainly in the forward fuselage.

A Canadian Armed Forces helicopter surveyed the runway and accident site about 45 minutes after the occurrence. Pieces of aircraft engine including the propeller and other components were strewn for some 2000 to 2500 ft along the runway. The pilot overflew the crash site and observed the wreckage still burning, and in fact the heat from the fire was still intense. The helicopter pilot described the weather as variable, with good visibility to the east but restricted to the south and west; there was no icing. He was able to fly VFR along the flight path presumably flown by CF-QBL. There were fog patches in the area and a fog bank over the river but these did not affect ceiling and visibility until later.

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2.0 ANALYSIS

2.1 Impeller Failure

At the last engine overhaul Modification 1732 was incorporated on the failed impeller. MOD 1732 is intended to eliminate fretting on the first stage impeller rear abutment face where it mates with the case hardened steel sealing sleeve. Part of MOD 1732 requires machining a minimum of 0.005 inch of metal from the rear abutment face to remove existing fretting damage. Per D.R.S. 528 the impeller is then tested for indications of cracks after the machining process. This may be a logical time for attempting penetrant crack detection, since penetrant inspection before machining would lead to probable masking of crack indications by the multiple indications resulting from fretting damage which would be present even if no crack were present. The problem is however that any cracks still present after machining will be doubly difficult to detect because the actual machining operation will inevitably tend to close the cracks (by virtue of smearing a thin surface layer over the crack lip). Any cracks present will be "tight" in any event.

During this overhaul procedure two cracks were not detected by the specified inspection procedure. The presence of these undetected cracks, in the impeller, led to subsequent catastrophic failure.

No material deficiencies were contributory to the impeller failure.

2.2 Performance

After the forward section of the engine separated, the combined drag from the engine frontal area, cowlings and landing gear increased drastically. It is estimated that initially while the engine and cowls were separating, the aircraft yawed at least 15 degs to the right. This must have puzzled the crew because they had never experienced such a violent swing on any previous simulated engine failures.

The flight characteristics of the aircraft after damage are not known since the aircraft was not certified to fly with part of an engine having fallen off. Flight crews are also not trained to fly aircraft damaged to the extent of Flight 255.

Calculations indicate that for wings level an airspeed of 87 kts would have given the aircraft a 15.7 FPM climb rate. On the vertical speed indicator, in the flight deck, this would not have even shown as a positive climb rate; the increment is too small. For an engine failure after lift off the aircraft is certified to climb out at not less than V2 speed. Pilots are aware of this and trained accordingly. In this case the target V2 was 103 kts and the V2 minimum was 91 kts; the crew would have no reason to go below the V2 minimum speed except as a last resort to avoid striking obstructions.

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2.3 Flight Path

After the "bang" the crew started their emergency check for engine failure/fire and continued the climb. At about 120 feet they realized that the aircraft was not climbing as it should and the airspeed had decreased from 103 kt IAS to 92 kt IAS. At about the same time they realized that the landing gear had not retracted.

Both pilots had received numerous simulated engine failures during training and this failure by itself would not have created any great concern. When they realized that they were now faced with multiple failures which resulted in an aircraft with no climb capability, they must have become aware of the gravity of the situation. To re-land the aircraft from 120 feet altitude would mean running into obstructions off the end of the runway and would have been contrary to standard procedures and pilot training.

To turn left would be contrary to the airport approach plate instructions for runway 06, and it would have served no useful purpose anyway. To continue straight ahead, as called for in an emergency climb out procedure, with an aircraft that would not out-climb the obstructions ahead, would have been disastrous. The only choice remaining was a right hand circuit and land as quickly as possible. The Captain made a judgement call; he turned right, maintained visual contact, and attempted to coax the aircraft around in a close-in circuit for an emergency landing at the airport.

Weather conditions were not conducive for a VFR circuit. The visibility was restricted to 1 mile, although to the east of the airport it was better; it was also a dark night.

As the flight continued the pilots attempted to hold altitude. Calculations indicate that the aircraft would descend at about 40 FPM in the turn if 91 kt or more were maintained. They were too low to give up any height so they attempted to hold height and gave up airspeed. As they approached the College the airspeed was probably already below 90 kt or perhaps just above VMC. At about this time some passengers moved to the rear, creating a further aft shift of the C of G which was already outside the aft limits. There can be no doubt that the crew were overloaded with work and had control difficulties; the aft C of G compounded these control problems.

The full left rudder trim and full nose-down elevator trim is an indication of directional and pitch control problems. It is also indicative of a low airspeed and an aft C of G.

The aircraft was most likely at or near the same height as the obstruction lights on the College and both pilots would have seen them. At night these lights would look even closer than they were. The Captain may have pulled back on the elevators to avoid collision or the movement of the passengers to the rear may have caused the

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nose to pitch up. It is believed that the airspeed went below VMC at about this point and time. As directional control was lost, the aircraft yawed and rolled to the right, a high sink rate developed and the aircraft struck the ground about 7 seconds later.

Evidence from ground impact marks indicate that the aircraft was yawing to the right, (skidding to the left), when it impacted the ground.

Lactate tests from the pilot's autopsy indicate high stress levels starting at 15-18 seconds prior to impact for the Captain and 8 seconds for the First Officer. These could be related to times where the C of G shifted aft, for the Captain and to where the high sink rate started for the First Officer.

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3.0 CONCLUSION

Findings

The forward section of the right engine separated, and, along with the propeller, fell to the runway at a critical time after take-off.

Separation of the engine was due to the bursting of the low pressure impeller, caused by a fatigue crack which existed prior to the last impeller modification and overhaul.

The specified inspection procedure, in use at the time of the impeller overhaul, did not detect the crack.

The landing gear, although selected up, would not retract, most probably due to engine debris damage in the electric gear selection circuitry.

After engine separation, the aircraft performance was drastically degraded due to increased drag from the extended gear, exposed engine and lower cowl.

With the resultant drag, in the aircraft's configuration, it was neither capable of out-climbing obstacles straight ahead nor capable of maintaining altitude during the right turn.

Engine separation and passenger movement resulted in the centre of gravity shifting beyond the aft limit, thereby degrading the longitudinal stability.

During the final stages of the flight, probably in an attempt to maintain altitude, the airspeed decreased below minimum control speed, resulting in a steep descending turn and the aircraft struck the ground at or below VMC.

It is considered that the crew faced an impossible control problem and under the circumstances did all possible in endeavoring to maintain control of the aircraft.

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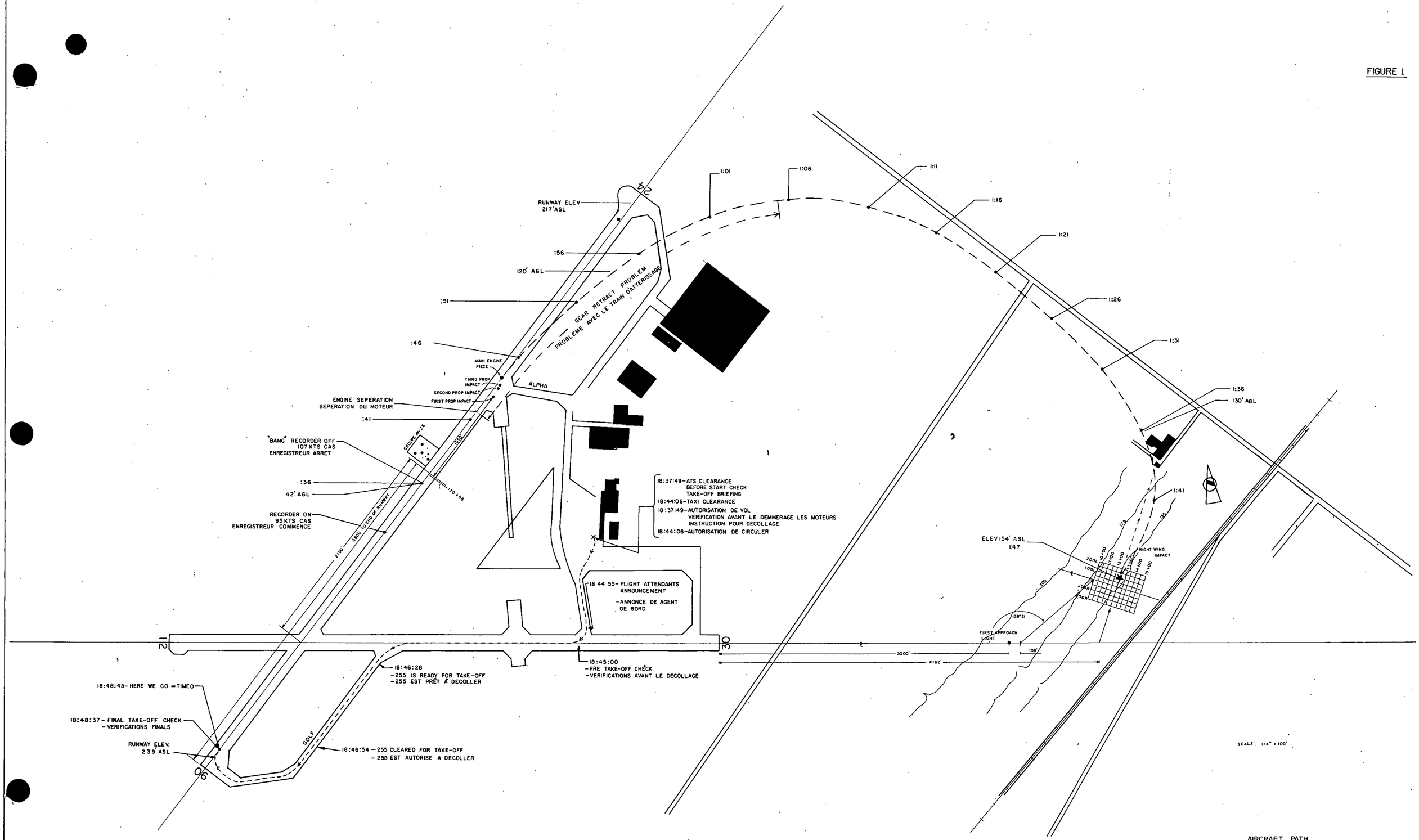
FIGURE I.



AIRCRAFT PATH
QUEBECAIR FL 255
F-27 CF-QBL
29 MARCH, 1979
QUEBEC CITY, P.Q.

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FIGURE 2.

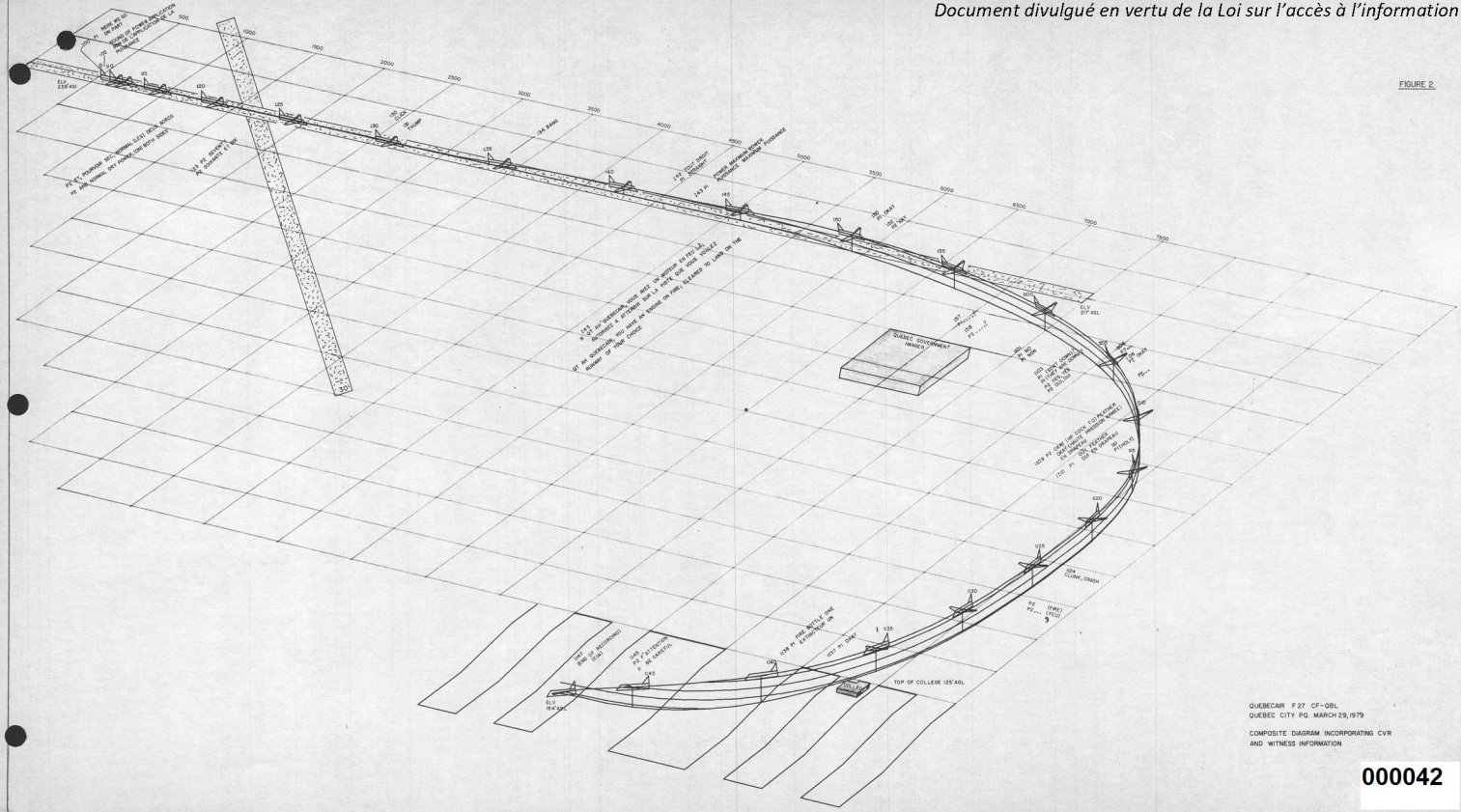

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FIGURE 3
IMPACT SITE - WRECKAGE PLOT
CF-QBL

SCALE - FT.

0 25 50 75

DIRECTION OF TRAVEL

038
006
007
014
013
009
008
012
016
018
054
017
005
010
050
024
040
011
053
043,055
045
LEFT ENGINE HOLE
015
042
044
041
023
022
020
019
039
052
021,048
003
049
047
046
051
033
RIGHT ENGINE HOLE
004
028
037
025
026
027
031
032
034
RIGHT WING TIP GROUND SCAR
030
002
001
239°M
035
029
036

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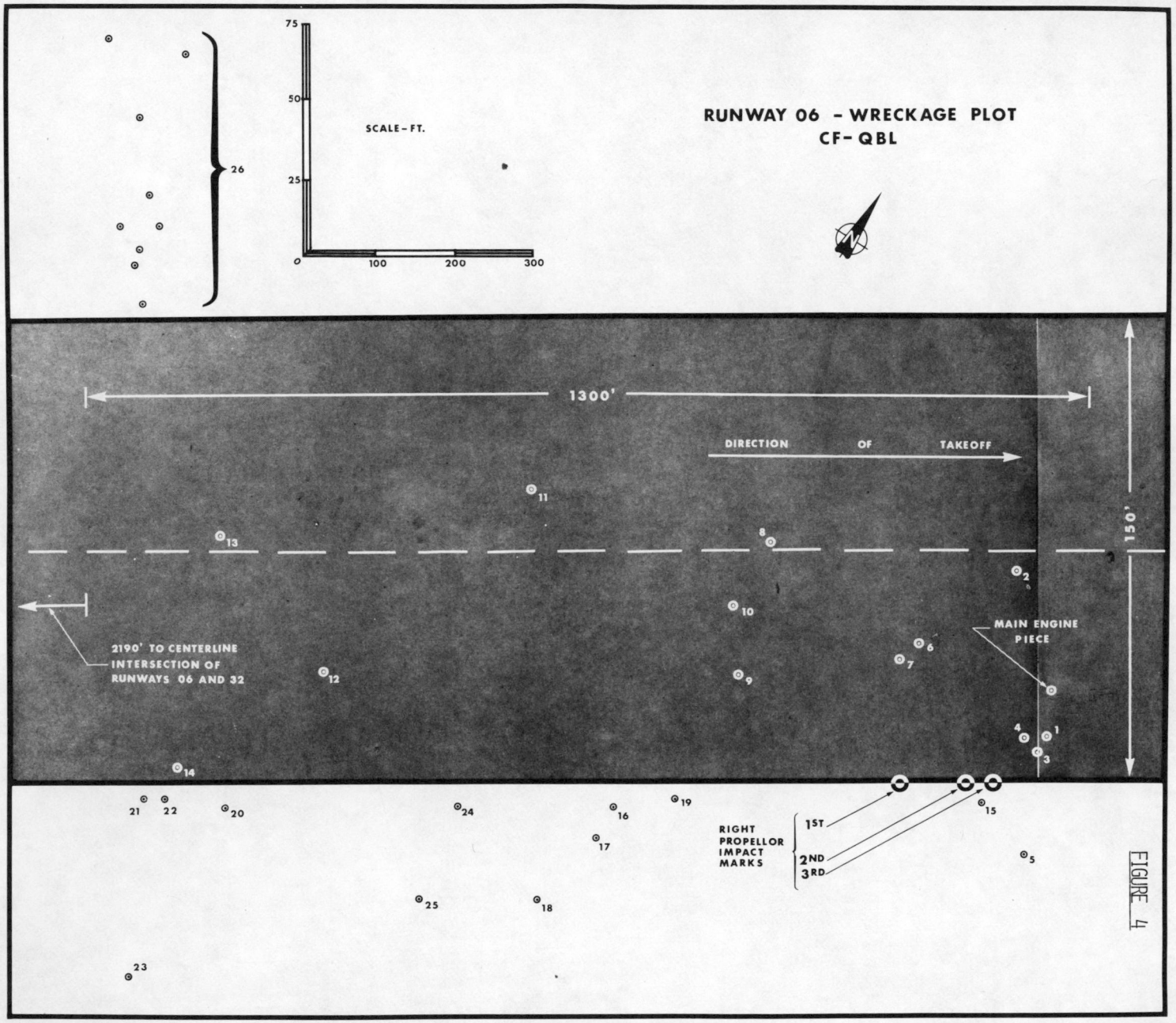

FIGURE 4

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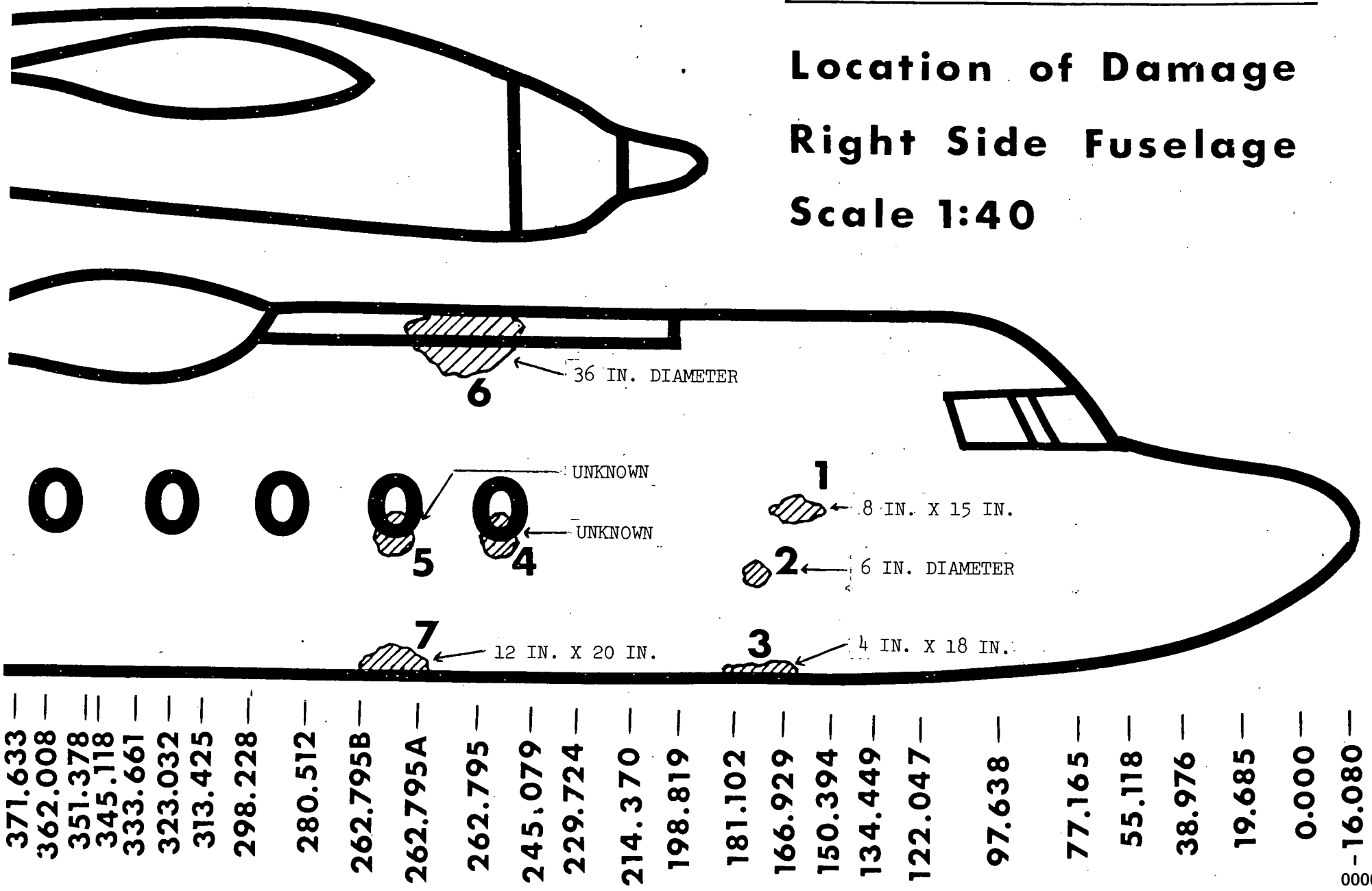
FIGURE 5

Sudan F27 Accident

Location of Damage

Right Side Fuselage

Scale 1:40



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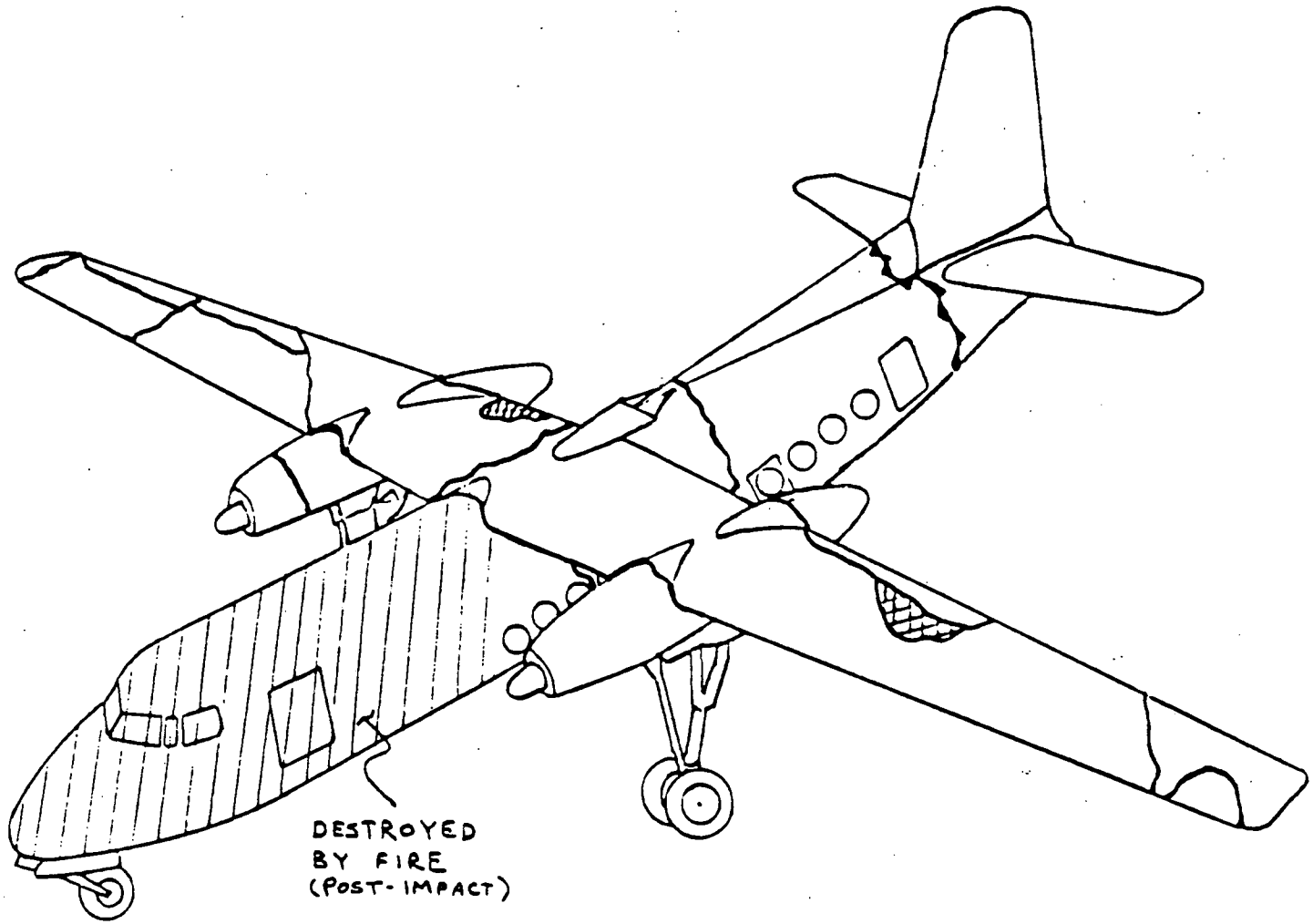

FIGURE 6

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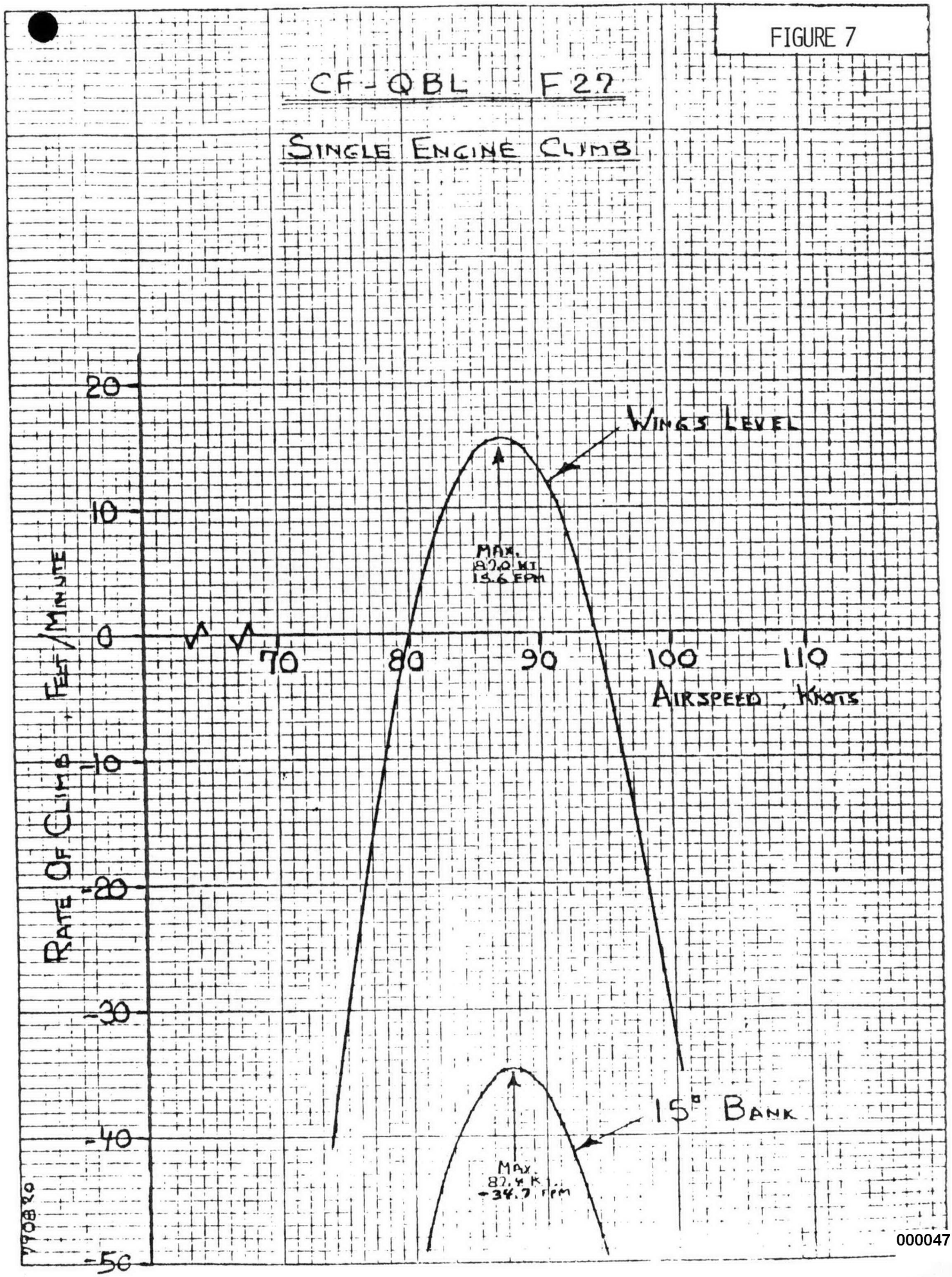
FIGURE 7

CF-QBL F27

SINGLE ENGINE CLIMB



7908R0

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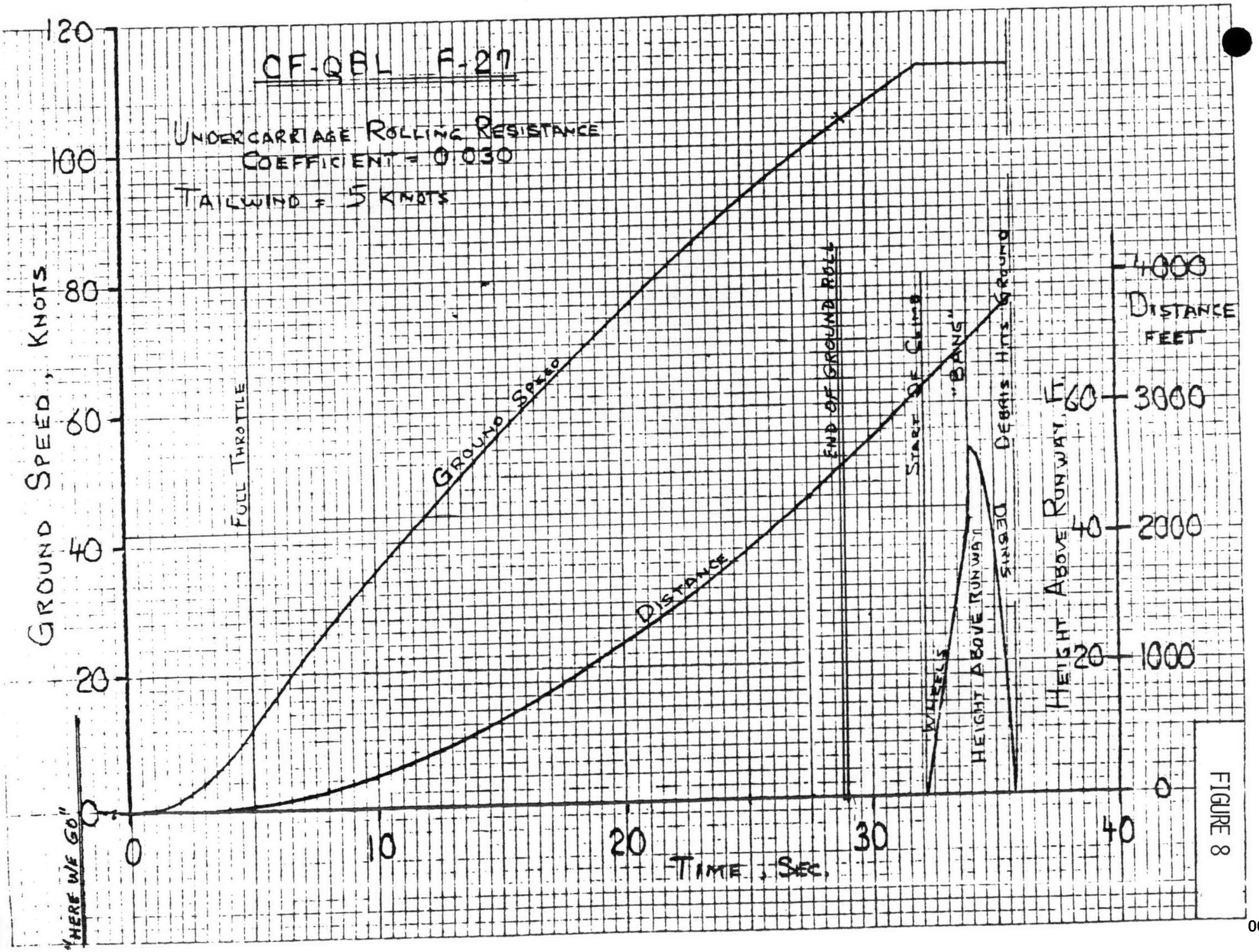

FIGURE 8

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APPENDIX A

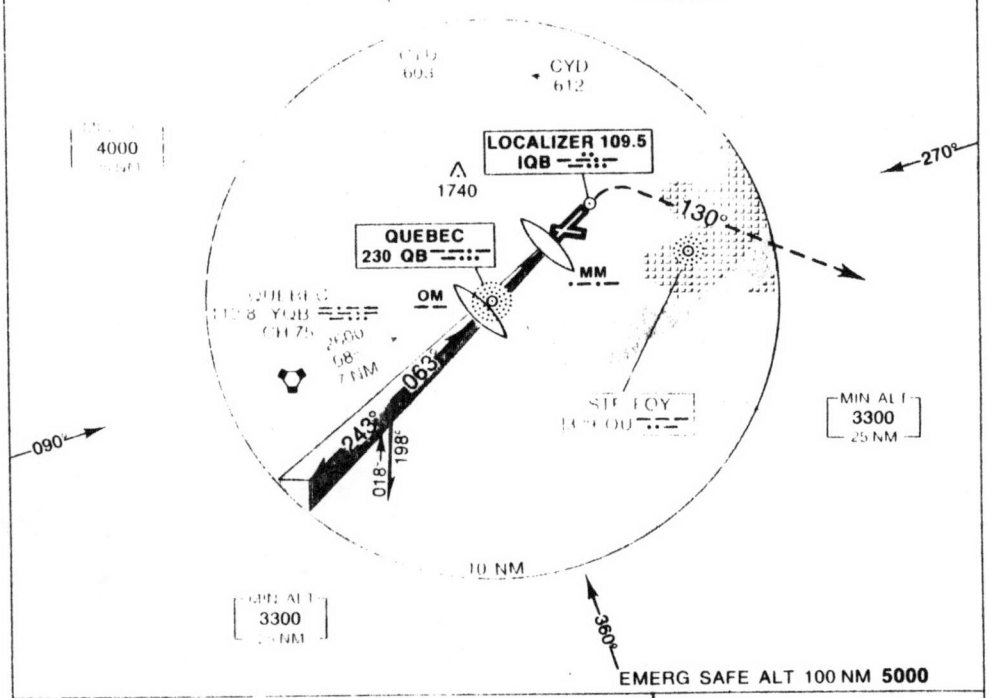
ILS-RWY 06

Produced by Surveys and Mapping Branch
Department of Energy, Mines and Resources

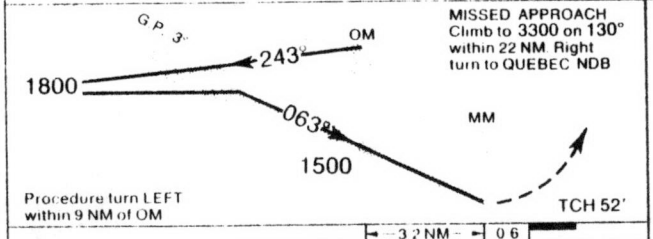
QUEBEC
QUEBEC QUEBEC

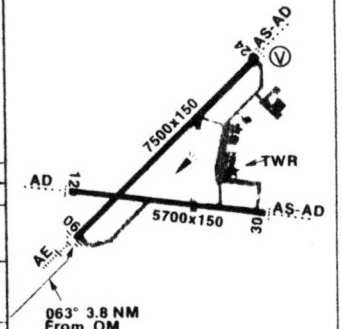
ATIS	ARR	TWR	GND	DEP	ELEV 239
121.0	119.5 322.8	120.3 236.6	121.9	119.5 322.8	TDZ 06 239

* All circling southeast Rwy 06-24 or southwest Rwy 12-30



EMERG SAFE ALT 100 NM **5000**





CATEGORY	A	B	C	D
FULL ILS	540	(301)	½ RVR 26	
	MIL 440	(201)	½ RVR 26	
HIAL INOP	540	(301)	1 RVR 50	
	MIL 440	(201)	¾ RVR 40	
G/P INOP	540	(301)	1 RVR 50	
* CIRCLING	840 (601) 1½		840 (601) 2	940 (701) 2

OM to threshold 3.8 NM

Knots	70	90	110	130	150
Min Sec	3:15	2:32	2:04	1:45	1:31

ILS-RWY 06

EFF 14 JUN/79

46 48 N-71 24 W VAR 18 W

CHANGE ATIS freq deleted

QUEBEC QUEBEC
QUEBEC

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APPENDIX B

SID — Produced by Survey and Mapping Branch, Department of Energy, Mines and Resources — QUEBEC / QUEBEC QUEBEC

VOT	ATIS	GND	TWR	DEP
115.7	121.0	121.9	120.3 236.6	119.5 322.8

SID PROCEDURES

QUEBEC ONE

Rwy 06

1. Climb on runway heading to 1500' then right turn to 080° for radar vectors
2. Maintain 5000'
3. Contact Departure Control

QUEBEC TWO

Rwys 12 & 24

1. Climb on runway heading for radar vectors
2. Maintain 5000'
3. Contact Departure Control.

Communication Failure - Transpond Mode A/3 code 7600

On recognition of communication failure 10 minutes or less after take-off and in IFR weather conditions proceed as follows:

1. At 5000' proceed directly on course
2. Do not climb above last assigned altitude for 10 minutes after recognition of failure (Transponder equipped aircraft 5 minutes) Then
3. Climb to flight plan altitude

NOTE: If communications failure occurs more than 10 minutes after take-off, comply with appropriate procedure for communication failure enroute

SID — 46-38 N 71-41 W — VAR 18 W — QUEBEC QUEBEC QUEBEC

EFF 12 JUL/79 — CANCEL ATIS 115.7 deleted

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APPENDIX C

QUEBECAIR S.E. CLIMB-OUT PROCEDURES

BG 11&29	R/T to BG between 1,000 & 1,500' AGL
BG 18&36	L/T to BG between 1,000 & 1,500' AGL
GA 04	Immediate L/T to GA, climb to Proc Turn or MEA in L/H holding I/B 045.
GA 22	Drct to GA, climb to Proc Turn or MEA in L/H holding I/B 045.
GP 29	R/T to intercept track of 303 from GP, climb to 1,000' AGL, then R/T to GP and track 123 I/B to Proc Turn or MEA.
GP 11	R/T to GP and climb to Proc Turn or MEA on O/B approach track.
QB 06	Track Localizer to BV, R/T to track Localizer to QB
QB 30	L/T to 250 within 1½ minutes of start of T/O roll
WK 01	Track 035 O/B from WK beacon
ZV 31	L/T to Z beacon between 1,000 & 1,500' AGL

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ENGINE FAILURE/FIRE

H.P. COCK.....CONFIRM & FEATHER
FEATHERING BUTTON.....PUSH-CHECK LIGHT OUT
CHECK FOR FIRE/IF FIRE EVIDENT:
FIREWALL FUEL SHUT-OFF.....PULLED
FIRE EXTINGUISHER.....SHOT #1 (30 SECS LATER:)
FIRE EXTINGUISHER.....SHOT #2

1) CABIN SIGNS.....AS REQUIRED
2) BOOST PUMPS.....OFF
3) FUEL TANK VALVE.....CLOSED
4) WINDSHIELD TRANSFER....LIVE ENGINE
5) DEICING GENERATOR.....OFF
6) DC GENERATOR.....OFF/MONITOR MAX 400 AMPS

ENGINE FIRE ON START

BOTH H.P. COCKS.....CLOSED
START BUTTON.....PULL TO CANCEL START
BOOST PUMPS.....ALL OFF
FUEL TANK VALVE.....CLOSED
FIREWALL FUEL SHUT-OFF.....PULLED
FIRE EXTINGUISHER.....SHOT #1
CALL GROUND EQUIPMENT
F/O TO REAR TO AID IN EVACUATION
CALL "EASY VICTOR" THREE TIMES ON P.A.
FIRE EXTINGUISHER.....SHOT #2 (IF REQUIRED)
CRASH BAR.....HOLD DOWN FIRMLY
CAPTAIN TO EXIT AND AID IN EVACUATION

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ITEMS ON RUNWAY 06-24

1. Front compressor casing lower R/H containing piece of air intake flange
2. Pipe with banjo fitting P/N RK 10330
3. Front comp casing top R/H side cooling air EI60W
4. Unidentified small piece
5. LP RGV and part of shaft
6. Half LP impeller
7. Half LP impeller
8. Sump portion LP casing and intermediate case flange 6 o'clock position
9. 6" section LT harness
10. Piece of flange intermediate case 1-1/2" long
11. Top cowl and inboard side cowling
12. LP cooling air pipe
13. Half section fwd outboard cowling
14. Half section rear outboard cowling
15. Reduction gear quill shaft front end
16. Front comp casing ID 12" long
17. Piece front comp casing outer circumference inside flange
18. Front comp casing and air intake casing flange
19. Piece of volute casing
20. Piece of volute casing
21. Piece of volute casing
22. Various pieces of volute casing, including right gear manufacturer's data plate
23. Front comp
24. Imp. shaft
25. Imp. backplate
26. Bag containing various pieces of front and intermediate casing found on L/H side of runway consisting of 16 pieces plus one washer (diffuser bolt).

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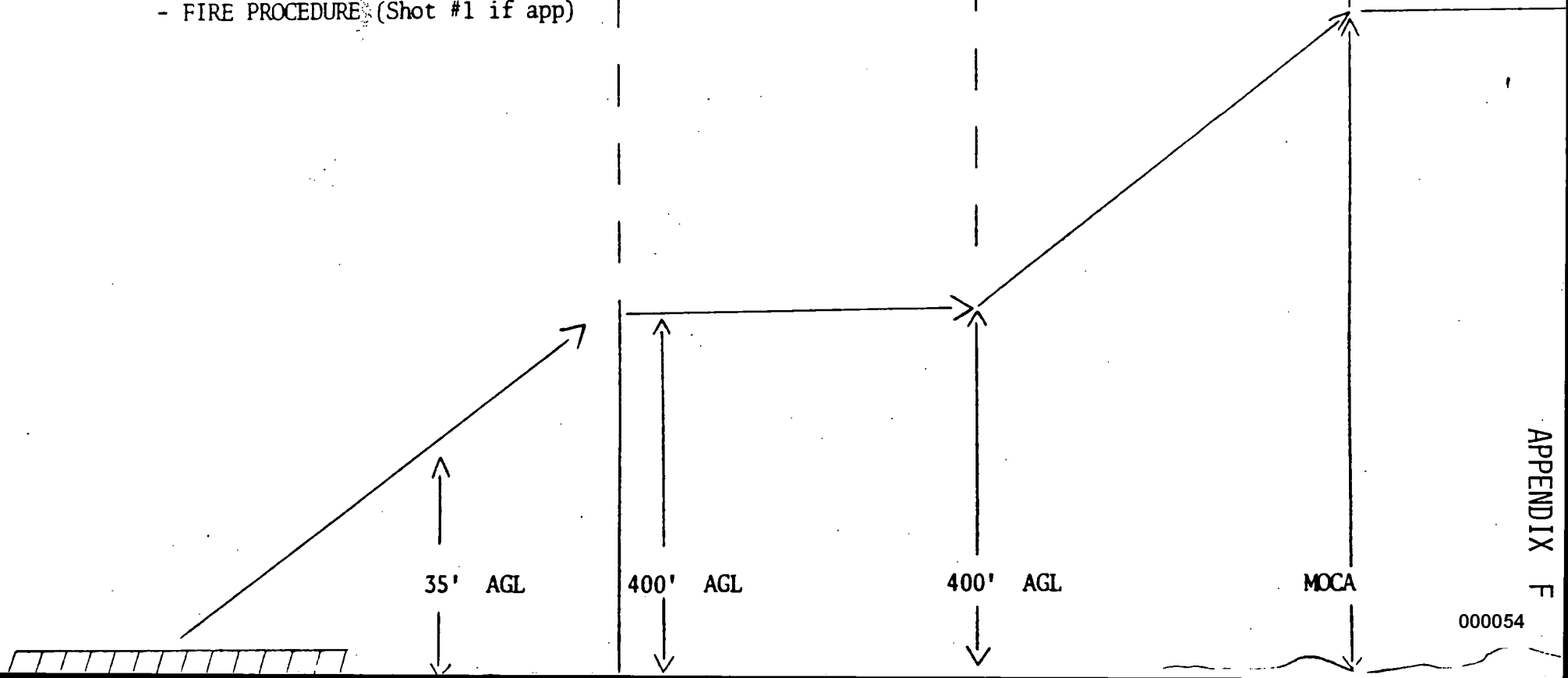
F-27 Engine Failure After V_2

Power: 600/595 14,500		650 14,500	540 14,000
Speed: V_2	F/R - S.E. Climb	S.E. Climb	Cruise

- STRAIGHT/PWR/DRAG
- CONFIRM & FEATHER ENGINE
- FIRE PROCEDURE (Shot #1 if app)
- FLAP RET'N/SHOT #2
- METO PWR
- DECLARE EMERG
- CHECK-LIST



APPENDIX F